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# The Engineer

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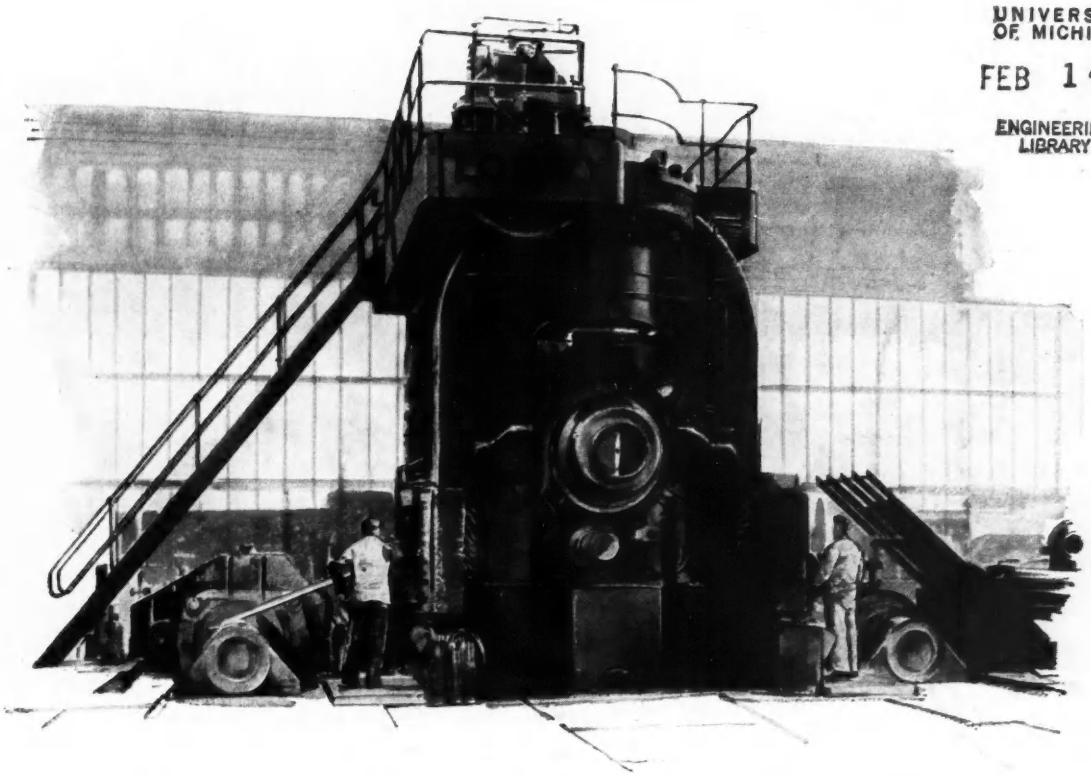

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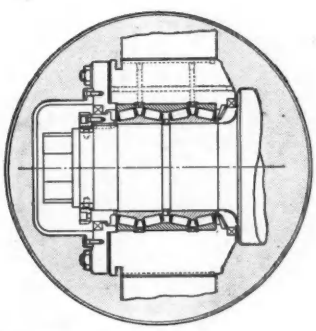

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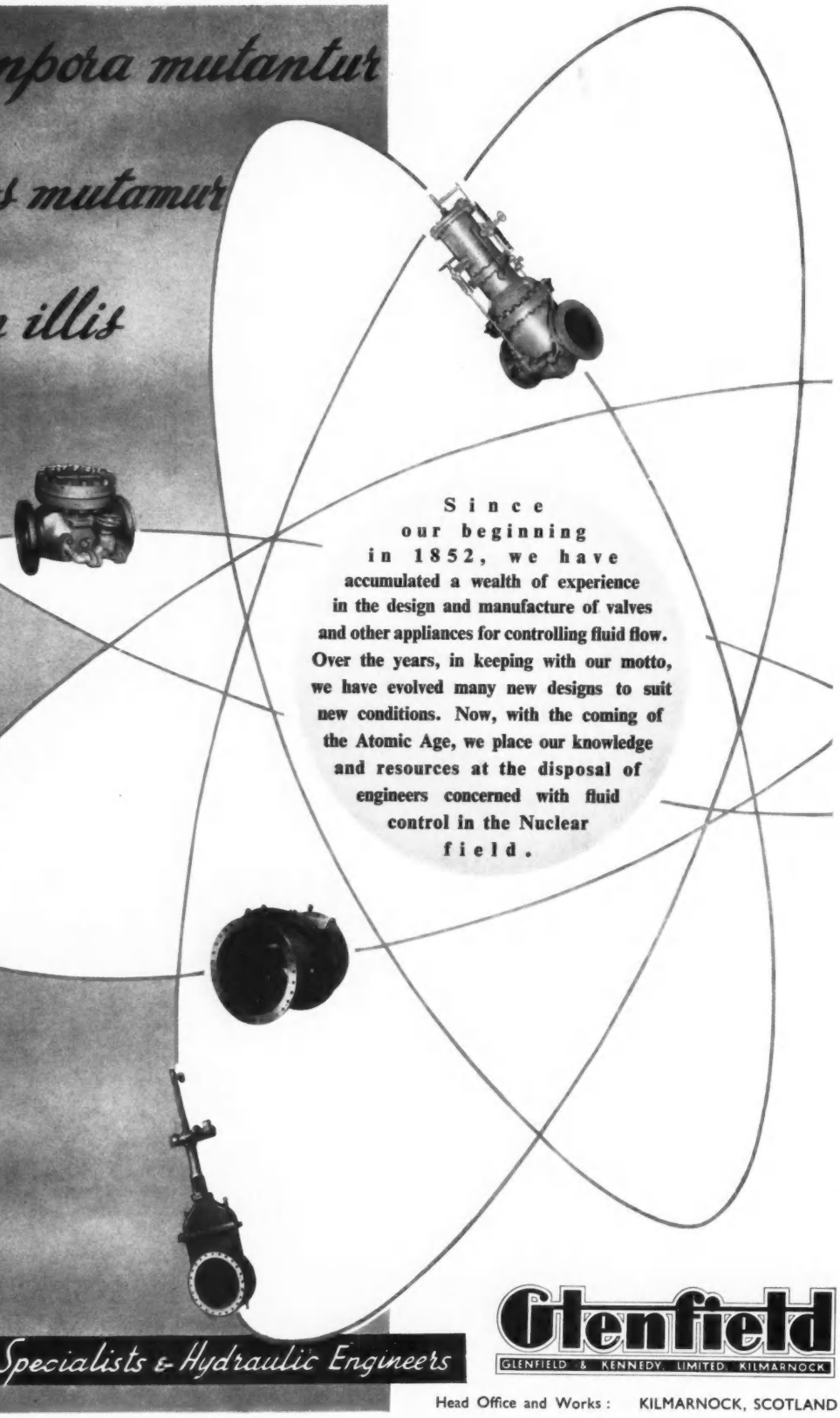

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# THE ENGINEER

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SIXTEEN ART PLATES


## SCIENCE OR SERVICE?

Committees have always been considered fair game by the critics. Time and again their ways have been held up to scorn and derision. All of us at times having doodled away a whole morning at a committee, have added to the chorus of abuse. Yet are committees, as Sir Lawrence Bragg suggested in a letter to *The Times* on January 3, really such terrible time wasters ? Would they continue to exist if they were ? The fact that despite all the abuse they suffer committees tend to multiply in number rather than diminish should make us pause. Indeed, in this country hardly any important decision nationally, industrially, or in quite domestic affairs, is taken except as a result of a discussion in some form of committee even if it be held only around the fireside with father in the chair ! Originally, we suppose, the committee system was created out of the idea that two heads are wiser than one. That proposition may possibly be true; but there is no evidence at all to suggest that ten or twenty heads are even better still—rather the reverse ! The lively go-ahead man of ideas more often finds so many heads obstructive. The real purpose, excellently served, of a committee is to scotch opposition at birth. For it is a curious point in the psychology of most men that they object less to a committee decision with which they disagree than to a decision, even though obviously the right one, taken without any hearing being given to their views! Thus a good chairman, even when it is obvious to him what a decision ought to be, even when he knows that those few members of a committee who have bothered to think about it beforehand agree with him, will still insist upon a discussion of alternatives. For he knows there is nothing more likely to arouse ire and opposition amongst the rest than a suspicion that a proposal has been bulldozed through the committee. Necessarily this business of reaching agreement is time consuming. Yet when, at the expense of giving a hearing even to stupid and misconceived comment, an agreement is reached, it usually proves lasting and acceptable amongst all those people or organisations represented on the committee. Nobody cares, once the decision has been taken, to act in direct opposition to it. It may be odd that we maintain such loyalties ; but the unanswerable retort to many an argument amongst those affected by a committee's decision is " the committee in its wisdom decided otherwise."

But Sir Lawrence Bragg's attack was not confined to committees. He was rather railing against administrative duties of all kinds interfering with the main business of a scientist, which he conceived to be the job of getting on with his science. But this is something that not only scientists suffer from. We all do. The tyranny of the fixed agenda on a committee, the lengthy and laborious business of approving reports upon actions taken or of the results of sub-committee work, are matched by the equal tyranny of the in-basket and the out-basket at the office, the engagement book, and the telephone bell. There is always urgent administrative work to be done. We should all of us, and not scientists alone, like to have far more time for study and for thought, more time to develop our own ideas. But is there not a certain suspicion of nostalgia about that desire ? Amongst engineers, at least, we all look back with pleasure to the days when we were younger and when we were doing " real " engineering ; when we were actively making something, inventing something, or designing something, or really getting down to experimental work in a laboratory. More and more as we get older we find ourselves involved in paper work and discussion. But is not this the right progression ? For there is no evidence whatever that younger men are less intelligent than their elders. They are just as capable of doing the active work. What they lack is experience, the experience that gives the older man wisdom in choosing between alternative paths, in criticising results and in understanding human nature. With age and experience, too, there comes a greater fertility of mind in devising expedients for overcoming difficulties, and a greater stability of mind, neither unduly cast down by failure, nor unreasonably exalted by success. The young tend to fling themselves against brick walls. Only occasionally do they break them down. The more elderly prefer to walk along the wall looking for the gate ! But if this discussion of the qualities of youth and age has pretensions to being right, clearly older men are better employed in encouraging, directing and criticising the work of the young, and in suggesting roads to further advance, in short, in administration, than in doing the active detail thinking or working themselves. Their value is more widely effective that way.

But there is still more to be said. Many scientists and engineers find it irritating to have to explain their conclusions to laymen. Sympathy can certainly be expressed. For it is usually very difficult to put into the ordinary words that a layman will understand a theorem or a scientific conclusion that can be expressed succinctly in a jargon or even more precisely as an equation. Nor is it easy, without appearing aggravatingly self-opinionated or arrogant, to demonstrate to laymen how one thing hangs technically upon another, why for example, if a dam is to be built across a river, an arch dam is appropriate at one

possible site and quite inappropriate for an alternative site a few hundred yards away. It is not even easy to convince people that scientific methods can make any contribution to the solution of their problems. Well do heads of research establishments know it ! If the scientific work of professional engineers is to serve mankind as it could, then it is essential that the contribution it can make should be well understood, as well understood as the contributions made by doctors, lawyers, accountants and members of many other professions. We fully agree, therefore, with the reply to Sir Lawrence Bragg made by Mr. Emmerson, Director of Research at the G.K.N. research laboratories : " Science in industry will only become truly effective when scientists and technologists are completely integrated with all levels in industry and themselves concerned to see their results applied." That result will certainly not be attained if the older and more eminent men shut themselves up in their laboratories. Hermits, no doubt, have the most wonderful thoughts. But they are not very helpful in improving the lot of the rest of mankind !

#### BALLISTIC ROCKET ERA AND THE NAVY

The development of guided and other self-propelled missiles is still carried on in this country behind a curtain of secrecy, ostensibly for security reasons, but, as probably, because little real progress has been made. We are asked to be patient, and meanwhile to be content with the knowledge that an air-to-air guided missile has been issued to the R.A.F. for operational training, and a surface-to-air missile is now under test for the use of the Fleet. It is not, therefore, surprising that the British people are unaware of the potentialities of the self-propelled missile in its various forms or of the remarkable progress that has already been made in the United States. In particular the American anti-aircraft guided missile has reached such a stage of reliability and effectiveness that various types are in quantity production and have been issued to all three of the United States Fighting Services. The American defence chiefs are indeed convinced that these missiles provide a sound defence against the bomber and that the need is urgent for another kind of explosive carrier to supplement, if not entirely to replace, the bombing aircraft. They have for several years been investigating two types of alternative long-distance explosive carrier—a winged missile propelled by a ram-jet or other similar engine, on the lines of the German V1 flying bomb ; and a ballistic rocket, with a trajectory beyond the atmosphere, a development of the V2.

Considerable progress has already been made with the winged missile and two varieties of it, with a range of 500 miles, are now in use as an auxiliary to the main armaments of the U.S. Navy and Air Force—the " Regulus " in the Navy and the " Matador " in the Air Force. Until comparatively recently efforts had been largely concentrated on increasing the range of these missiles and there are two types with an intercontinental (5000 miles) range under development which show great promise as a weapon of the reasonably near future. All these winged missiles, however, though they can be guided throughout their trajectory, must remain within the atmosphere—below 100,000ft. Moreover, with engines dependent on air for the combustion of fuel, their speed is relatively slow—certainly insufficient to render them immune from anti-aircraft measures. On the other hand, there are difficulties in producing a very long-range ballistic rocket, particularly because of the inability of the materials at present available to withstand the heat friction developed when the missile is re-entering the atmosphere at speeds of something like 4 miles a second. The " Atlas "—a rocket of this kind with a range of 5000 miles, now under investigation in the United States—is still, in fact, very much a weapon of the more distant future.

Latterly, however, two new developments have caused a marked revival of interest in the ballistic rocket and concurrently in the importance of sea power. Tests have shown that both nuclear and even thermo-nuclear explosives can now be used in a warhead of reasonable size, which makes accuracy of far less importance. There has also been very great progress in methods of combustion and propulsion, and the American authorities now seem satisfied that the design of a relatively short-range rocket is, in essence, suitable for missiles of up to 1500 miles' range. The Chrysler Corporation has, in fact, been given the contract for prototypes of the ballistic rocket " Jupiter." This rocket has a range very much greater than the " Redstone," a one-stage rocket of the same design with a range of 250 miles, which is already in production. The " Jupiter " is to be tried out at sea in two large merchant ships now being converted for the purpose. In brief, priority is being given to producing what is at present practicable, leaving the intercontinental ballistic missile to be developed in due course as a weapon of the future. Rockets of up to 1500 miles' range, to reach vital targets, must be launched from positions off an enemy's coast and because of their size require large ships to carry a worthwhile number. This means little change in the function of the United States Navy which has under construction, a fleet of six supercarriers—each of 60,000 tons and costing £70,000,000—for launching A3D bombers at targets 1000 miles inland. The Americans have always in mind the fear that their land-based bombers may be partially or even totally destroyed by a sudden, unexpected attack and these naval bombers provide an alternative strategic bombing force. But what of the Royal Navy ? Will its primary task in the missile era remain, as hitherto, to guard the sea communications ? Or will the intermediate range ballistic rocket of the early future give a new impetus to the principle of hitting the enemy where it hurts him most ?

## The Engineer
### 100 Years Ago
(JANUARY 9, 1857)

" CONSUMPTION OF SMOKE UPON RAILWAYS "

" On Monday a case of some interest was heard before Sheriff M'Farlane, at Paisley, involving the right of the public to compel railway companies to consume the smoke of the fuel burned in their locomotive engines. Some time ago the magistrates of Paisley brought an action against the Glasgow and South-Western Railway Company, before Sheriff Glasgow, for having permitted one of their engines to pass through Paisley, along the line, while emitting dense volumes of smoke. A penalty of £5, by one of the clauses of the Railway Companies' Act, was exigible when a case of this kind was proved. The fact of the engine having smoked was clearly proved ; but for the railway company it was contended that they had done what the clause of the Act founded on by the complainer required of them—they had fitted up the engine on the most approved principle for consuming its own smoke ; and the same engine was capable of consuming its smoke if properly tended.

" The pursuers, in reply, urged that, according to the spirit of the enactment, the railway company were bound not only to construct their own engines on a smoke-consuming principle, but were under an obligation actually to consume it, or use a fuel which did not emit smoke. The Sheriff Substitute, Mr. Glasgow, appeared to be guided by the last consideration, and decerned for the pursuers, finding the railway company liable to the penalty. This decision was appealed against, and parties were heard before Mr. Sheriff M'Farlane on Monday. Mr. Young, advocate, appeared for the railway company, the appellants, and Mr. Patten, advocate for the magistrates of Paisley. Sheriff M'Farlane said that the distinction in this case was a very narrow one, and there was room for hesitation on the matter. The disputed point appeared to be this, whether by the clause of the company's act founded on, they were bound to do anything more towards the consumption of the smoke of their locomotives than by constructing them upon the best known principle at the time of doing so."

## Obituary
### DAME CAROLINE HASLETT

SINCE the time of the first world war, Dame Caroline Haslett has been closely associated with many activities of the engineering and electricity industries of this country. She was well known to a large number of people engaged in those industries, and was known also to numerous others by the prominent part she took in public affairs. All will deeply regret Dame Caroline's death, which occurred after many months of illness, on Friday, January 4.

Caroline Haslett was a native of Worth, Sussex, and was educated at Haywards Heath High School. Her association with

the engineering industry started during the first world war, when she joined the office staff of Cochran and Co., Annan, Ltd. During her service with that company she asked to be transferred to the works, and undoubtedly the experience thus gained deepened her appreciation of the part that women could well take in technical matters. The work accomplished by women in the engineering industry during the 1914–18 war led to the formation, in 1919, of the Women's Engineering Society, and it was most appropriate that Caroline Haslett should be invited to become its first secretary. As the work of that society progressed, the development of the domestic uses of electricity became more and more marked, and in 1924, Dame Caroline was among those who felt that there was a place for the Electrical Association for Women which was founded in that year. Dame Caroline was appointed director of the Association, an office in which she continued until her failing health compelled her to resign at the beginning of last year. Her years

**Dame Caroline Haslett**

of energetic work with the Association will be long remembered ; she was convinced that through the wise use of electricity in the home, there could be achieved greater ease and efficiency. Under Dame Caroline's able direction, the Electrical Association for Women has undoubtedly rendered—and continues to perform—a useful service to the community.

Although Dame Caroline's work with the E.A.W. occupied, for over twenty years, so much of her time, there were many services which she ably gave in other spheres. She had the distinction of being the only woman member of the British Electricity Authority when it was formed in 1947, she was at one time chairman of the British Electrical Development Association, a member of the councils of the British Institute of Management and the Industrial Welfare Society, and a member of the Crawley Development Corporation. These were but a few of the public offices that Dame Caroline held ; there were many others. She was a Companion of the Institution of Electrical Engineers, and a Justice of the Peace. The value of her work was deservedly recognised by the award of the C.B.E. in 1937 and of the D.B.E. in 1947.

# A Seven Day Journal

### "Open Skies for Peace"

AN exhibition at the Royal Exchange, London, open until January 26, explains the application of aerial photography to a system of mutual inspection by the U.S.A. and U.S.S.R. to reduce the possibility of a surprise attack by either. The exhibition was opened on Monday last by Mr. Winthrop Aldrich, the American Ambassador, and Sir Cullum Welch, the Lord Mayor. The techniques displayed include the photography of a strip 490 miles wide by 2700 miles long, from Los Angeles to New York, by one aircraft in a four-hour flight. At the other extreme, a "Sonne Strip" taken with a moving film camera in a machine flying at 525 m.p.h. 60ft up, has been enlarged to show individual rivets on an aircraft on the ground.

### Research on Injuries from Road Accidents

A PAPER recently published by H.M. Stationery Office for the Department of Scientific and Industrial Research reviews the research which has been done, mainly in the United States, in connection with injuries sustained in vehicle accidents and related topics. In addition to describing the results of research in the United States, the paper suggests lines of research which might be followed in this country where road conditions and vehicles are different. It was found in America that when cars were in collision one or more doors tended to fly open, according to the point of impact. When the front doors opened one in three of the occupants of the car were thrown out—with a doubled likelihood of serious injury. The first requirement for reducing injuries is therefore stated to be to improve door fastenings or to adopt other methods of keeping the passengers inside the car if an accident should occur. It was found that even if occupants were kept in comparative safety within a vehicle there was danger from internal fittings against which they can be thrown during a crash. Much research has been done also on the value of safety belts for car occupants, and the best results were obtained with a combination of a shoulder loop belt and a lap belt. It is pointed out in the report that it should not be assumed that British experiments would lead to the same findings as those reached in the United States. The paper suggests for this country that research teams should investigate accidents on the spot immediately after they occur, and that experiments should be carried out to investigate the forces arising and the behaviour of vehicles and dummy passengers in collisions. Further work is also necessary on the design and trial of protective equipment.

### Urban Highway Maintenance

ON Tuesday last, a paper entitled "Organisation and Control of Highways Maintenance," by Mr. W. J. Hiscock, was read at the Institution of Civil Engineers. Mr. Hiscock is executive officer and highways engineer for the city of Leeds, and he had some interesting remarks to make on the organisation of the highways department there, and about some of the technical improvements introduced in the work which the department has carried out. When discussing the organisation of the department, he pointed out that during 1955–56 6 per cent of the total possible productive working man hours were lost from sickness. Mr. Hiscock believed that to be the result of a costly sickness scheme which was none the less little attraction to employees, 45 per cent of whom were over fifty years of age. The remainder, he affirmed, regarded work with the department, which paid lower salaries and wages than industry, as transit work while seeking higher-paid jobs with industry. He also criticised the "red tape" involved in local authority procedure, the engineer often having to refer to a committee before making a decision. "He is tied to maximum wage rates and plus rates ; he can neither reward initiative nor without considerable investigation and administrative detail dispense with inefficient and unproductive labour. In place of a minimum profit under private enterprise, the inevitable overhead charges inherent in the local government system have to be allowed for ; these go beyond costs of the department concerned and create a burden not found in private enterprise," he said. Mr. Hiscock laid particular stress on the need for planning work, details being planned at least eighteen months before the work was undertaken. Control during the progress of work was another essential, and he advocated weekly returns showing how actual costs were comparing with estimates. Great efforts were made to achieve economies ; for instance, it had been found out that despite the costs of overtime it was cheaper to surface roads on Sunday, as weekday traffic reduced output by half. Experiments were also being made with a new type of footpath based on burnt pit shale costing 6s. 9d. a square yard, against the 15s. 9d. of concrete flagging.

### Industry and Petrol Rationing

A REVIEW of the information available concerning the policies and regulations which have come into being since the beginning of the oil shortage is contained in a handbook entitled "Petroleum Rationing of Industry," published last week by the Federation of British Industries. It is pointed out that, as the situation changes still from day to day, the information presented in the booklet is that which was available at the "date of printing." Since the effects of the blocking of the Suez Canal have begun to make themselves felt, the F.B.I. has been in constant touch with Government departments, stating industry's point of view and drawing attention to its special needs. The booklet says that "when all has been done and whatever may be conceded it must, however, be accepted that many of us will have to meet severe shortage and discomfort." The need to seek the help and understanding of all employees over fuel economies is stressed. The Federation adds that, though there is probably still a lot wrong with present arrangements, it is doing its best to get them adjusted in the interests of saving loss of production. The inventiveness and powers of improvisation of all consumers of oil, both private and industrial, will, however, be the major factor affecting production losses. With this in mind, the F.B.I. reprints as an appendix to this booklet its leaflet, "Hints on Saving Fuel Oil," with the suggestion that it would make an agenda for fuel saving studies by individual firms. Details of the procedure to be followed for obtaining the basic and supplementary rations are included for both goods vehicles and private cars, together with notes on petrol and gas/diesel oil for industrial and miscellaneous requirements, other than road transport.

# Civil Engineering in 1956

No. II—(*Concluded from page* 23, *January* 4)

WE have already described the Preston by-pass motorway, construction of which started in 1956. Another highway topic which was well to the fore in 1956 was that of traffic in the large built-up area, and particularly in London. The British Road Federation's conference on urban motorways was the major event which drew attention to this problem, and was fully discussed in this journal at the time. But the conference was especially timely, and its conclusion, expressed as a resolution that "the economic needs and traffic problems of large cities demand the construction of urban motorways" was reinforced by several other specific events. In passing, we should point out that it was not considered that urban motorways alone provided a complete solution to a city's traffic problems, but needed to be considered rather as the basic element in overall planning.

The way in which traffic congestion dominated the London scene in 1956 (or did so until petrol rationing was introduced) was exemplified by the rejection of two major development schemes. The New Barbican scheme in the City proposed a comprehensive development of 47½ acres of severely bomb-damaged ground. The Minister of Housing and Local Government, Mr. Sandys, spoke very highly of the scheme, and said that he had been greatly impressed by its imaginative character. Nevertheless, he rejected it, because it would increase congestion in Central London. Similarly, proposals for development around Victoria Station, involving projects for a multi-storey garage, large offices, a hotel, flats, and an air terminal with a helicopter landing ground over the station, were rejected by the L.C.C. The projects were, at least partly, "welcomed in principle," but the Council considered that any developments should be on comprehensive lines directed towards easing congestion and not adding to it.

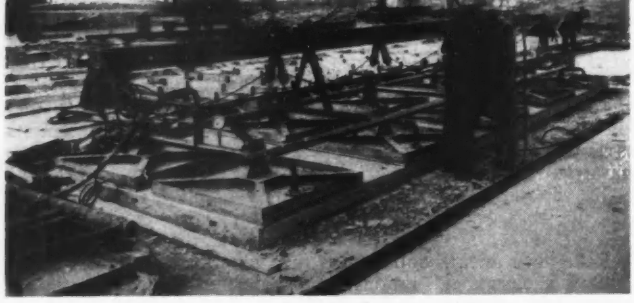
There appears to be no practicable alternative solution to London's traffic problem, but that of building a system of motor roads. The ring road scheme put foward at one time by the L.C.C. was commented upon at the British Road Federation's conference, when the opinion was expressed that, even amongst the costly standards of urban motorway schemes, it was the most expensive yet devised. Alternatives, like the proposed Victoria tube line, however, appear to be more expensive still. It was never claimed that the ring road scheme was the best or most economical choice for a main traffic artery in Central London; as far as we are aware, however, no more promising scheme has been investigated in great detail, and the formulation of a really practical plan for London's traffic—that could be compared with Mr. Drake's Lancashire road plan, for example—is still awaited.

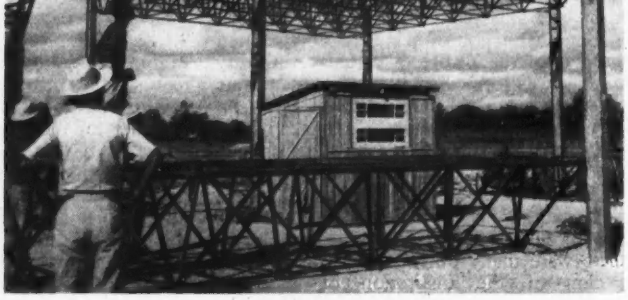
The second largest road scheme in progress in 1956 was the Cromwell Road extension in Western London. The scheme has been described as the first major road scheme in London for fifty years, and did in fact constitute the major constructional effort of the year towards alleviating congestion in London, though several smaller schemes were also in progress. It is in two sections, and is partly the responsibility of the L.C.C. and partly of the Middlesex County Council. The L.C.C.'s part of the scheme came in for some heavy criticism during the year, when the British Road Federation published a report it had commissioned from independent consultants, concerned mainly with the junction at the Hammersmith end of the road. Traffic surveys had indicated that the roundabout there would be inadequate, the report pointed out, even for existing traffic, and inclusion of a fly-over road, construction of which had been deferred by the L.C.C., was considered essential. At the time, we pointed out that a serious aspect of the report, in our opinion, was the criticism by implication that adequate "origin and destination" surveys had not been carried out when the new road and its junctions were planned. Furthermore, the enormous roundabouts characteristic of this and other recent L.C.C. designs, seemed to be open to grave criticism on grounds of safety and traffic capacity. We commented quite fully on the report in our issue of July 27 last.

A complementary aspect of city congestion is that of parking; several interesting developments occurred in 1956. Two systems of multi-storey parking were under consideration, at the end of the year, for sites in the City London of and central areas. They have in common that each car is driven to an entrance bay and is subsequently handled by a "dolly" and lifts, possibly with completely automatic control throughout. In the "Rotapark" system, lifts are placed centrally in a circular building, with a ring of parking stalls on each floor which can be rotated into position to face the lifts. The "Autosilo" system is somewhat similar, but incorporates vertical and horizontal movement, to or from the required parking stall, in the system of lifts. On the sites considered, parking capacities of around 300 to 500 cars were envisaged. Yet another proposal, put forward last December, but requiring an Act of Parliament before it can be realised, was that for an underground park to hold 350 cars in Finsbury Square in the City.

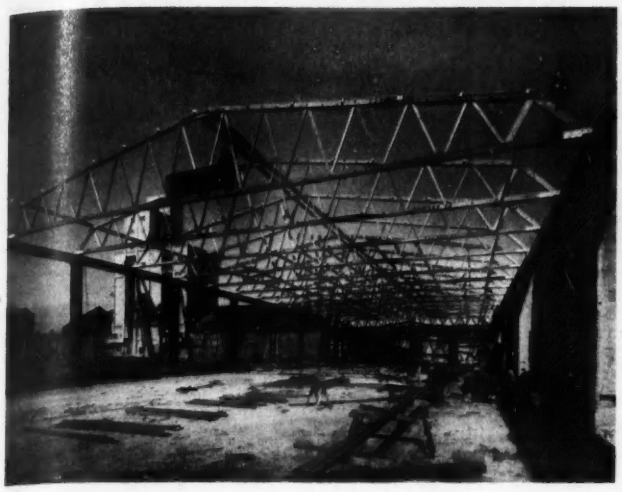
Apart from the schemes already mentioned, contracts for a number of other highway schemes were let during 1956. Most of these schemes were small, in comparison with the national need, and related to improvement of one kind or another of the basic pattern of roads already in use. Attention was drawn to the need for certain large-scale projects, especially bridges, in a discussion on the economics of toll highways held at the Institution of Civil Engineers last March. Reference was made to an impressive array of long-span bridges and tunnels, most of which have been designed in detail, but at present actual construction is not in sight. Contracts were let, however, for two schemes of this kind during 1956. The Dartford-Purfleet road tunnel, a scheme started before the war, but since held in abeyance, was briefly described in our issue of April 27 last, when the main contract was let. The scheme will cost more than £10,000,000; the tunnel itself will be 4700ft long, and will have a single 21ft carriageway. Soon afterwards (THE ENGINEER, May 4 last), it was announced that a contract had been placed for the construction of the Runcorn-Widnes bridge. This bridge will be a steel arch structure with a main span of 1082ft. It will cost more than £2,000,000.

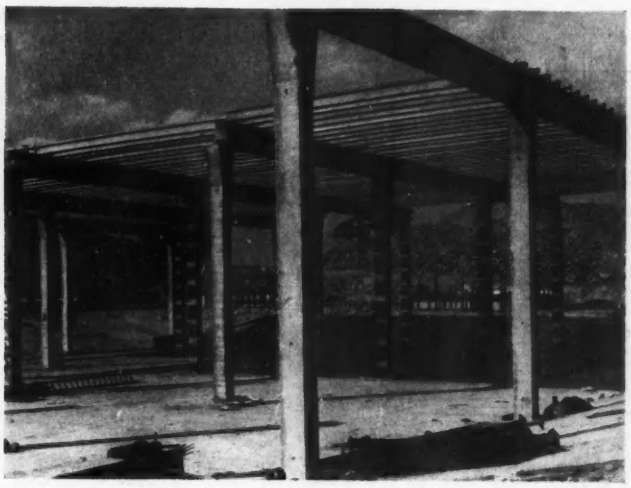
In the actual technique of construction, there is a great measure of similarity between road and airfield work. An account of recent developments in airfield runway construction was given by Mr. F. R. Martin, of the Air Ministry, at the Cement and Concrete Association's meeting last October (see THE





**(Left) Precast slabs for an experimental prestressed concrete runway platform. Suction lifting pads are in place ready for lifting a slab. Note the compressed air cylinder used to give an initial "lift" to the slab by blowing air beneath it. (Right) Prefabricated space frame. The basic element is a framed pyramid. Two rows of pyramids assembled as a unit for erection, with their bases uppermost and apices joined by tie rods, are shown in the foreground.**





(Left) Several large storage sheds built of timber were erected in 1956. Here we show erection in progress of the 88ft span timber trusses of the 500 yards long dock shed being built by the Mersey Docks and Harbour Board. (Right) Higham service reservoir. The main beams span 27ft 3in between columns, which are 22ft 6in high. Columns, main and secondary beams are precast and prestressed. Beams are simply supported, and light-weight concrete infilling completes the roof

ENGINEER, November 9 last). Some of this work is of special interest, and one aspect of it would appear to have a bearing on road construction, too, for one of the requirements discussed was a smooth surface calling for tolerances of $\frac{1}{8}$in variation in 10ft and of $q$ values of 30in per mile. A tool known as a "scraping straight-edge" (a 10ft straight-edge mounted on a long, pliable handle and used somewhat like a broom) was considered the essential item for success—rather surprisingly when it is contrasted with the complex train of equipment used to build a concrete runway. Other problems had to be solved, however, particularly with the joints, and the harsh no-slump concrete mix was no longer favoured for this work.

The heaviest loads imposed on aircraft runways present unique problems. The use of prestressed concrete has been proposed for such cases ; one of the main problems here has been the friction between the slab and the ground at the time of stressing. Mr. Martin described the laying of a 200ft square of jointless prestressed concrete platform, in which precast slabs were lifted by vacuum pads on to dwarf walls, which supported them $\frac{1}{4}$in above a prepared base. The slabs were then stressed, and finally the cable ducts and spaces below the slabs were grouted under pressure. The vacuum lifting gear is illustrated herewith.

Another experimental work of some interest, completed and described during the year, was the Oxton by-pass extension, about which Mr. R. A. Kidd presented a paper at the "Civils." This job was considered to have set standards of design and construction for future road works. Plant adapted from airfield construction was used, so that the full 24ft of carriageway could be concreted in one operation. A target of 40in per mile for surface irregularity was considered reasonable. A second experimental road, construction of which the Road Research Laboratory has awaited for some time, is that at Alconbury Hill, on A1 in Huntingdonshire. The contract for this work was let in the middle of the year. The behaviour of different kinds of construction on clay subsoil will be studied at this site.

Yet another interesting job was the Longton by-pass scheme in Lancashire, referred to last week. Here, 10in thick concrete carriageways, constructed in one operation, will be built, in contrast to the wet macadam construction of the Preston by-pass. In the Longton scheme, one carriageway will have a single layer of reinforcement and air-entrained concrete, and the other will have a double layer of reinforcement without air entrainment. Expansion joints with dowel bars will be at 150ft intervals and on the singly reinforced carriageway only, contraction joints in addition will be sawn in the concrete at 25ft intervals. A longitudinal joint will be sawn $1\frac{1}{4}$in deep in the centre of each carriageway. Kerbs will be laid on the concrete carriageway slabs and concrete backing to the kerbs will be dowelled to the slabs.

### STRUCTURAL ENGINEERING

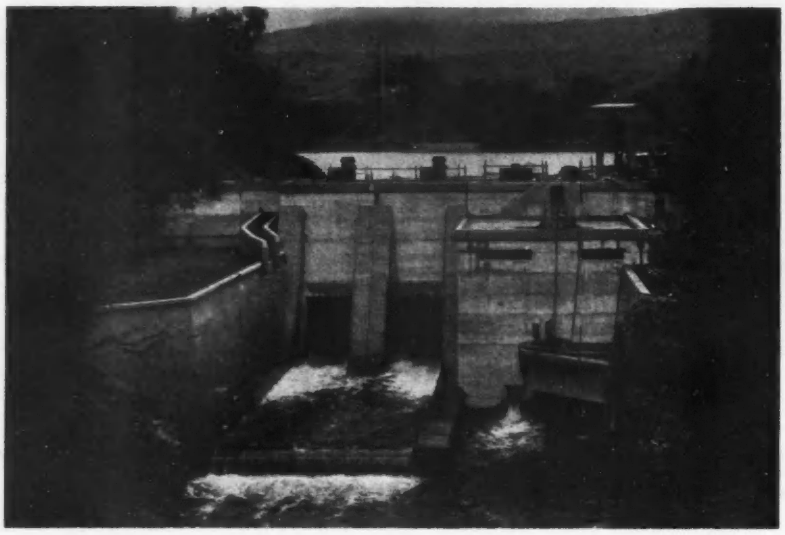
Brief information is given here of only one or two characteristic structural achievements of the year. First we should mention two noteworthy events in theoretical work, both of them described in papers presented at the Institution of Civil Engineers. On January 17, 1956, two papers on the experimental and mathematical analysis of arch dams were presented by Pippard, Chitty, Allen and Severn. The work was specifically concerned with an analysis of the Dokan arch dam in Iraq. The relaxation method of analysis was used ; a three-dimensional relaxation problem of such complexity had not before been attempted. The method was novel, as applied to arch dams, and theoretically sounder than the various earlier methods which have been devised for this complicated task. Turning now to steel structures, two papers on the design and testing, respectively, of plate girders were discussed at the Institution on February 28 last. A design method based on the revised British Standard 153 was described by Kerensky, Flint and Brown. The complicated expressions for critical stresses were reduced to a more usable form, and tables were introduced to simplify the design of girders with unequal flanges. By modifying the approach to stiffeners it was expected that the economic range of plate girders would be extended, and generally, an overall economy of 10 to 15 per cent in the weight of steel used was expected from the new design method.

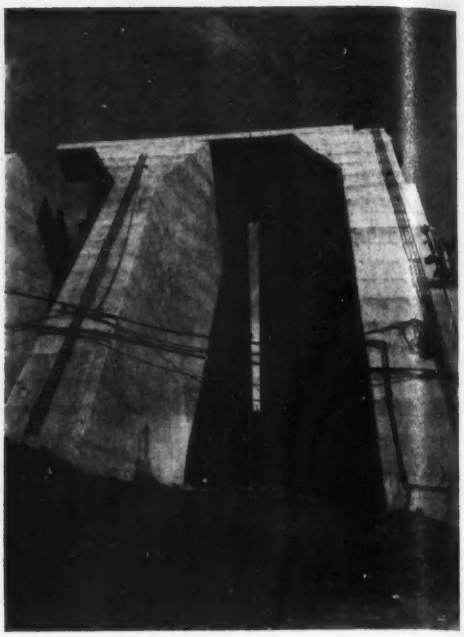
Some examples of heavy structural steelwork were illustrated in Plate 2 last week. A development in the lighter class of structures is illustrated opposite where we show erection in progress at Rangoon of a roof comprising a space frame prefabricated from pyramid-shaped basic units. Each unit has a square base formed from four angle members, with tubes welded on at each corner and meeting at the apex. The "pyramids" are assembled with their bases uppermost, and the apices are joined by tie rods. An assembly of pyramids ready for erection is shown in the foreground of our illustration, with a section of completed roof steelwork behind it. The system is very flexible ; parts of the frame can be left out, or column positions changed. Total strength is related to the system and not the individual members. The basic 4ft by 4ft pyramid can be built up into a bridge of 40ft span, complying with Ministry of Transport loading, or a roof on a 60ft by 60ft grid of isolated columns or a 108ft by 108ft grid springing from edge beams. This structural system was devised by Messrs. Bolton, Hennessey and Partners.

Timber structures were also used increasingly, and the illustration above shows construction of a large dockside shed in progress for the Mersey Docks and Harbour Board. Full-scale structural tests were carried out on the trusses of this design. An intensive programme of development in the structural usage of timber has been in progress for some years now. The Timber Development Association, which is carrying out this work, opened new testing premises during the year. One especially interesting piece of development work involved a framed timber roof analogous to the thin concrete "shell" roof. A quarter-scale model of this structure was built for testing during the year. The full-scale structure, as at present envisaged, involves framed panels of timber, each 8ft by 4ft in size, which would be bolted together to form the "shell" roof 80ft by 20ft in size. A very light structure would result, and no centering would be needed to erect it.

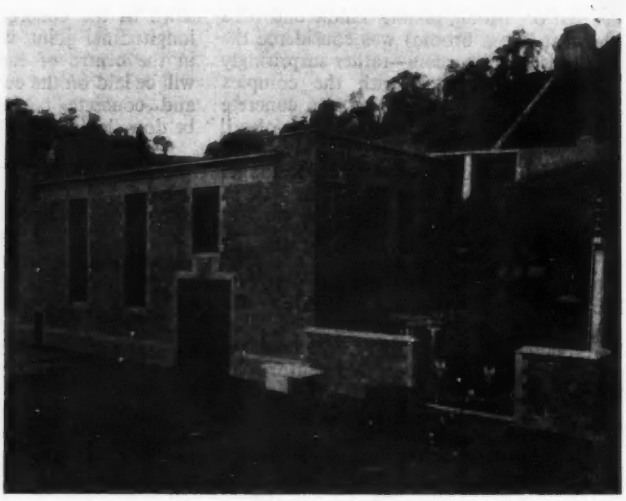
Another aspect of prefabrication is illustrated by the railway bridge shown below. Complete fabrication and rolling into position has been practised for many years, but although this method remains one of the best, it may not always be possible or desirable. If full advantage is taken of the capacity of the largest steam breakdown cranes, it is possible, in certain circumstances, to lift in completely prefabricated spans. Several bridges on the London Midland Region of British Railways have been reconstructed by this method in recent years, the largest being the one shown, carrying the

# HIGHLAND WATER POWER





Several of the North of Scotland Hydro-Electric Board's installations which were completed, or reached an advanced stage in 1956, are illustrated on this page. Garry dam (above) has to cater for sharp floods, and in addition to the two sluice gates shown, there is a spillweir, discharging into a tunnel, on the left bank. The dam has a Borland fish lift and two compensation-water generating sets (consultants, Sir William Halcrow and Partners; contractor, Whatlings, Ltd.). Two of the round-headed buttresses of the Shira dam are shown on the right, with the precast overhanging crest units in position (consultants, Babtie, Shaw and Morton; contractor, A. M. Carmichael, Ltd.)



The two power stations illustrated are Ceannacroc (left) of the Moriston scheme, and Finlarig (right) of the Lawers scheme. Ceannacroc is the Board's first sizeable underground power station and has one 16MW and one 4MW generating sets installed (consultants, Sir William Halcrow and Partners and Kennedy and Donkin; contractors, Mitchell Construction Company, English Electric Company, Ltd.). Finlarig has a 30MW horizontal-shaft Pelton wheel set (consultants, James Williamson and Partners and Merz and McLellan; contractors, The Cementation Company, Ltd., British Thomson-Houston Company)

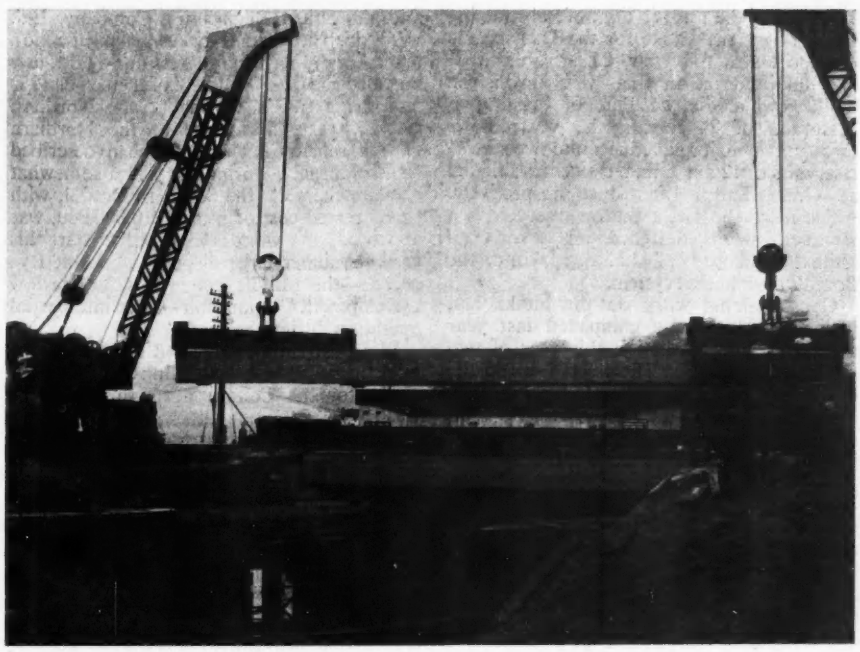
Errochty dam (left) forms the reservoir of the upper stage of the Tummel Garry scheme. It is a diamond-headed buttress dam, and makes an interesting comparison with the Shira dam shown above (consultants, Sir Alexander Gibb and Partners; contractor, A. M. Carmichael, Ltd.)

main line to the north over a public road near Warrington. The bridge has a skew span of 47ft 11in centre to centre of bearings, and is constructed in two halves. Each half is of the through type and carries one line of sleepered track on ballast, thus constituting two separate bridges side by side. Each structure consists of two welded steel main girders with rolled steel joist cross beams encased in concrete spanning between them. The floor is completely waterproofed and the webs of the main girders are fully protected by brickwork filling between the flanges—brickwork being chosen to reduce shrinkage to a minimum. The exposed flanges of the girders are protected by a heavy coating of a plastic bitumen compound.

The main unit, weighing 72 tons, was lifted on to a special wagon by two 50-ton steam breakdown cranes and conveyed to site, where it was lifted into position. A reinforced concrete parapet beam was then placed, after which a precast ballast wall unit was placed at each end of the main unit. The steelwork was fabricated by Francis Morton and Co., Ltd., and the assembly, concreting, brickwork and erection, &c., carried out by railway staff.

Prestressed concrete has now reached a stage where it is a normal part of the structural designer's repertoire. Thus, although a great deal of work was carried out with this technique in 1956, there is little to say about it here. One particularly fruitful field has been in light structural work, involving precast prestressed members, and some new systems of construction of this kind were introduced during the year. We give one example of this class of work. The illustration below shows construction of the Higham service reservoir, a part of the Ogston scheme of the North East Derbyshire Joint Water Committee, which supplies 1 m.g.d. to the new Avenue carbonisation plant of the National Coal Board.

The service reservoir will have a capacity of 5 m.g., being about 150ft by 300ft in size and 20ft in depth. The specification limited the number of columns to fifty, as against the 200 or so which a normal reinforced concrete design would require. The Water Committee's engineer is Mr. P. Hothersall; the roof structure was designed and built by the Concrete Construction Company, Ltd.



**Railway bridge unit of 72 tons weight being placed in position. Two such units constitute virtually the complete bridge. The first unit is shown in position**

## Water Supply and Sewage Disposal

Exhortations from Government authority, calling for amalgamation of water undertakings into regional grouping, were again heard in 1956. Another topic discussed at some length at Institution of Water Engineers' meetings, and also in these columns (April 27 and May 11 and 18 last) was the use of automation in pumping stations and in filtration plants. Automatic control is now well established in these classes of waterworks practice. Two water schemes, representative of constructional work in progress in 1956, are briefly described hereunder.

Kingston-upon-Hull is a city which has unusual problems of drainage and also of water supply. Much of the city lies below the high water level of spring tides, and an improved drainage system is under construction to eliminate risk of flooding. Some time ago, flooding and shortage of domestic water supplies occurred simultaneously—a situation particularly difficult to explain to the lay mind.

The present water supply of Hull is obtained from a series of adits and wells in the water bearing chalk beneath the city. Since the war the water demand has steadily increased, and despite extensive development of the chalk as a source of supply, the water department has at times been unable to meet this demand. However, the Corporation obtained a Water Order authorising the abstraction of an average figure of about 12 m.g.d. from the River Hull, and work on this project was started during the year. The points of intake are fixed at the lowest levels on the river at which total infiltration cannot occur. These are above Hempholme Lock, about 13 miles north of Hull.

The terms of the order provide for the cessation of abstraction when the river flow reaches a fixed low level, but permit an increased rate of abstraction at higher flows. So to obtain the full benefit, reservoirs with a total capacity of about 370 m.g. will be constructed to store water at flood times for use in dry periods. Two intakes are being constructed, of reinforced concrete, the first on the main river immediately above Hempholme Lock, and the second on a tributary about a mile north of this point. Inflow at each intake will be controlled by sluice gates. Water from these intakes will flow by gravity through 48in and 60in diameter concrete pipelines to a screening and pumping house containing rotary drum screens, &c., and then be pumped into raw water storage reservoirs. Provision will be made at this point for the injection of chlorine into the water to control weed and algal growth. Two large raw water reservoirs are being built to the west of the river bank downstream of the intakes.

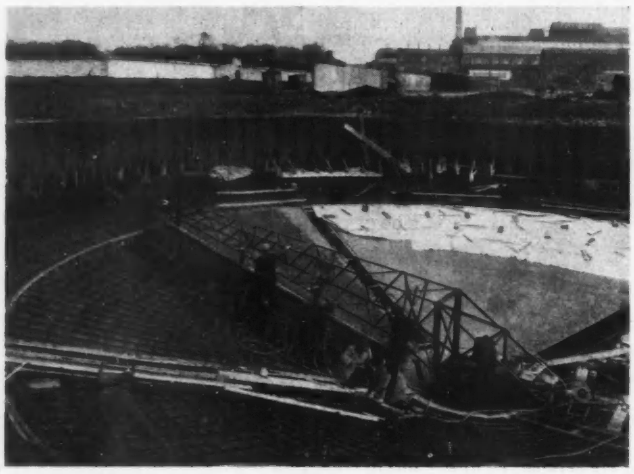
The depth of water in the larger reservoir is to be 12ft 6in and the surface area about 59 acres, whilst in the smaller reservoir the depth is to be 25ft and the surface area 26 acres. The walls of the reservoirs are of mass concrete gravity section and in the construction as a whole about a million cubic yards of excavation will be removed. Cut-off walls will be carried down to the surface of the boulder clay which underlies the whole site.

The raw water will be pumped from the reservoirs into vertical-flow flocculation tanks working on the sludge blanket principle. From these tanks the clarified water will gravitate through rapid gravity sand filters into a treated water reservoir of 5 m.g. capacity. Out of the reservoir the purified water will be sent direct to the city mains through about 10 miles of 36in diameter steel pipes. The pumps are generally of the vertical spindle type, driven by squirrel-cage motors, but those which pump the water to Hull are driven by 330 h.p. variable-speed motors controlled by induction regulators.

The electricity to operate the pumps and ancillary plant will be partly generated in the works, and five diesel-alternator sets will be installed to provide a capacity of 1050kW. The remaining electricity required will be taken from the grid.

The geological conditions of the site present many problems. The highest ground level at any point is not more than 15ft above sea level, and the surface layers consist of a mixed collection of silts, sandy clays and peat beds. These deposits overlie a continuous bed of boulder clay averaging about 20ft thick. On this are founded most of the structures. Beneath the boulder clay is a deep bed of broken chalk containing water at artesian pressure, and it is intended that the main buildings of the treatment works should be founded on piles penetrating to this bed. The cost of the scheme is estimated at over £1,000,000. The consulting engineers are G. H. Hill and Sons (Manchester), and the civil engineering contractors A. E. Farr, Ltd., and Arthur Monk and Co., Ltd.

The Dee scheme of the West Cheshire Water Board is another project of the same order of magnitude, largely completed during 1956. Work was inaugurated in 1950 with the object of supplying both potable and non-potable water to the growing population and expanding industries of Wirral, Cheshire. The scheme is being operated in conjunction with the Bala Lake scheme, whereby water is impounded in Bala Lake during periods of heavy rainfall, and later released into the River Dee during periods of low flow, to be abstracted through a number of intakes mostly situated in the vicinity of Chester. An inauguration ceremony for the Bala Lake scheme was held last summer, in June.



**Constructional plant in use at the Derby sewage works extension scheme. (Left) Rotary screed for a humus tank floor, fabricated from a 10R.B. turning table and a crane jib. (Right) Conveyor installation for placing filter medium**

To avoid the possibility of abstracting saline water, the intake for the Dee scheme was located at the Weir, Chester, the limit of tidal influence in the river. From the intake, which is capable of passing a maximum of 24 m.g.d., the water flows through two major aqueducts into two service reservoirs of 12 and 6 m.g. capacities situated at Great Sutton and Ince respectively. Adjacent to the Great Sutton reservoir is a treatment works designed for passing an ultimate quantity of 12 m.g.d. into the Board's distribution system.

Constructional work on the intake and major aqueducts was completed last year except for the installation this year of two more pumping sets. These sets are capable of pumping 6 m.g.d. against a head of 230ft and are driven by 6·6kV motors.

The covered reservoir at Great Sutton is circular in plan and has a depth of 26ft. It comprises mass concrete walls, a reinforced concrete counterfort mid-wall extending to the full height of the reservoir, and reinforced concrete beam and slab roof. The inlet has been designed so that micro-strainers can be accommodated should a partially treated water be required for industrial usage, or, alternatively, for by-passing a section of the treatment plant. Work on this contract began in 1954 and testing of the reservoir was approaching finality at the end of the year.

The treatment plant consists of eight upward-flow sedimentation tanks, six rapid gravity filters, a 2 m.g. contact tank, pumping station, three sludge concentrating lagoons and ancillary works. The plant has been designed to operate on a fully automatic basis and employs alum as a coagulant and activated carbon for taste removal. Constructional work began in 1954 and plant installation commenced last January. It was hoped, at the time of writing, that it would be possible to commission the works partially to provide a temporary supply of water by the end of the year.

Work on the reservoir at Ince, which is of a similar design to that at Great Sutton, began in December, 1955. To date the mass walls have been completed, together with a large part of the lower floor slab, and construction of the mid-wall has started. Both reservoirs have been designed so that potable and industrial water may be stored at the same time without any danger of contamination. Messrs. G. H. Hill and Sons were also consultants for the Dee scheme, contractors being R. G. Horton (Engineers), Ltd., and the Salem Engineering Company, Ltd.

The largest schemes for sewage purification and main drainage in progress during the year included the East Middlesex scheme (Plate I) and the L.C.C.'s scheme at the Northern Outfall. The first stage of the Northern Outfall scheme has already been described in this journal ; during the year a somewhat similar scheme at the Southern Outfall, with an estimated cost of nearly £10,000,000, was approved, and work is expected to start this year. Another large disposal works at Rye Meads—the Middle Lee works for Harlow Development Corporation—came into partial operation during the year.

We illustrate two detailed aspects of the work in progress in extending the treatment works for the County Borough of Derby, which show some rather unusual plant. The screed for grading the circular humus tank floors was fabricated from a 10 R.B. turning table and a crane jib ; as well as screeding the newly placed concrete, it provides a platform from which a trowelled finish can be given to the work. The conveyor installation for medium placing is particularly comprehensive for this class of work. The filter medium—1½in graded granite aggregate—is loaded on to the conveyor by the machine shown on the right of the illustration, and distributed by the man on the left. The inclined conveyors are pivoted at the joints to allow free movement of the loading machine ; the final conveyor is cantilevered from the bridge and may be moved vertically or horizontally. With four men at work, medium can be placed at a rate of 30 to 35 cubic yards in an hour. The extensions in progress at Derby have an estimated cost of about £2,000,000. The consulting engineers are Messrs. J. D. and D. M. Watson, and the civil engineering contractor is Holloway Brothers (London), Ltd.

## Road Tunnel Under Lower Fraser River, Vancouver

AMONG the projects carried out in recent years by the Copenhagen firm of Christiani and Nielsen are a number of subaqueous tunnels, a kind of design which, in that firm's experience, appears to be coming to the fore more extensively. The firm has for instance, worked on the preliminary design for vehicular and railway tunnels between Denmark and Sweden, for a large road tunnel under the Göta River in Gothenburg, Sweden, and for a tunnel connection between the Swedish island of Oland and the mainland. The common aim in all these projects is to provide an economical and satisfactory arrangement for a traffic connection, without causing inconvenience to navigation and without having to overcome the large differences in levels which sometimes present a problem with high level bridges.

To a great extent, these projects were based on the experience gained by the firm in the construction of the road tunnel under the Maas River at Rotterdam, Holland.

During the past year a project has been studied, in collaboration with The Foundation of Canada Engineering Corporation, Ltd., for an additional highway crossing of the Lower Fraser River at Vancouver, Canada. The problem was to find the most suitable site for a crossing and to decide whether a bridge or a tunnel would be the better solution. As a result of the studies and investigations it was finally concluded that a tunnel at Deas Island would be the most advantageous. The findings were explained in a report which, in April, 1956, was submitted to the Minister of Highways, Victoria. After a study of the report by the British Columbia Toll Highways and Bridges Authority, it was decided to adopt the solution proposed, which was a four-lane highway tunnel. The contract was awarded to the two above-mentioned firms, and actual construction work has now started.

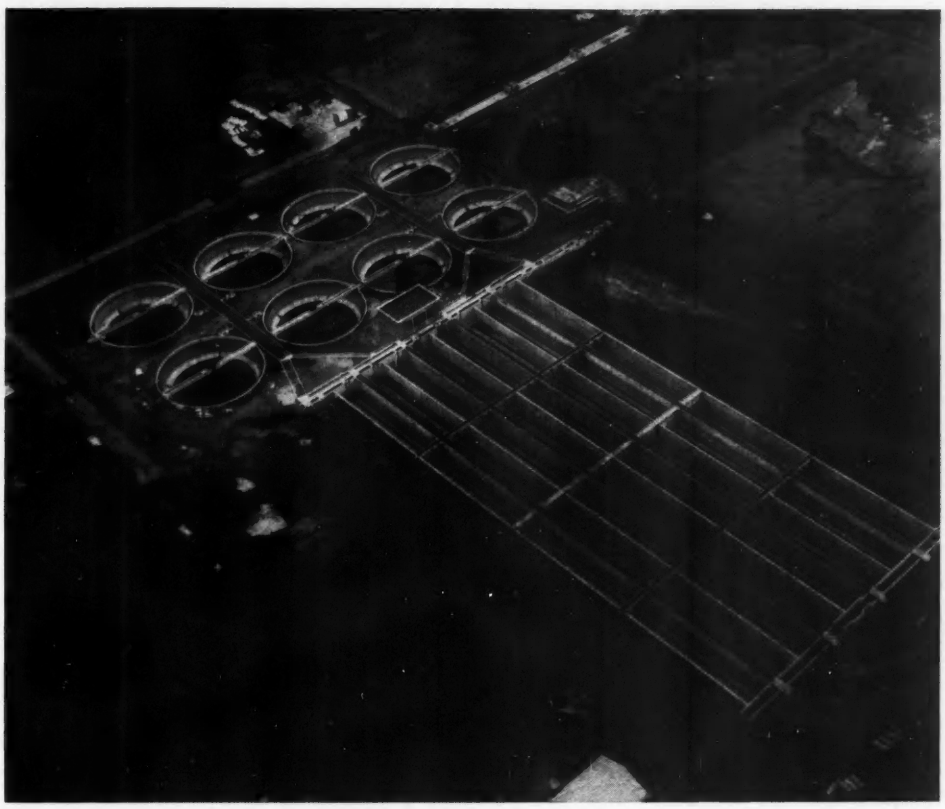
The length of the tunnel proper is 2165ft, and has been reduced to a minimum by extending the open approaches at both ends right out to the river banks. This arrangement considerably facilitates the ventilation, lighting and inspection of the tunnel.

The subaqueous tunnel is constructed of six shore-built reinforced concrete elements, each 344ft long, sunk in line into a dredged trench and then connected. Once all elements are in position, the trench is refilled with sand and protected with a layer of rockfill, which also covers the top of the tunnel. The tunnel is placed at a level which gives sufficient clearance above the tunnel for a future navigation channel, 1400ft wide and 30ft deep at low water. Four lanes, each 12ft wide, are provided, the vertical clearance being 14ft. A longitudinal partition wall separates the two two-lane roadways. Two ventilation ducts are provided on the outer sides of the roadway tubes along the entire length of the tunnel. The ventilation buildings, one on each bank, link the subaqueous tunnel to the approaches and form the entrance portals to the tunnel.

All technical installations, which include ventilation plant, installations for lighting and traffic lights, telephones, fire alarms, fire extinguishers, loud-speakers, television cameras, pumping installations, &c., are operated from a control room in one of the ventilation buildings. From this control room, the traffic situation on each roadway can be watched on television screens. The tunnel is due to be completed and opened for traffic in 1959.

# DEEPHAMS SEWAGE TREATMENT WORKS AT EDMONTON

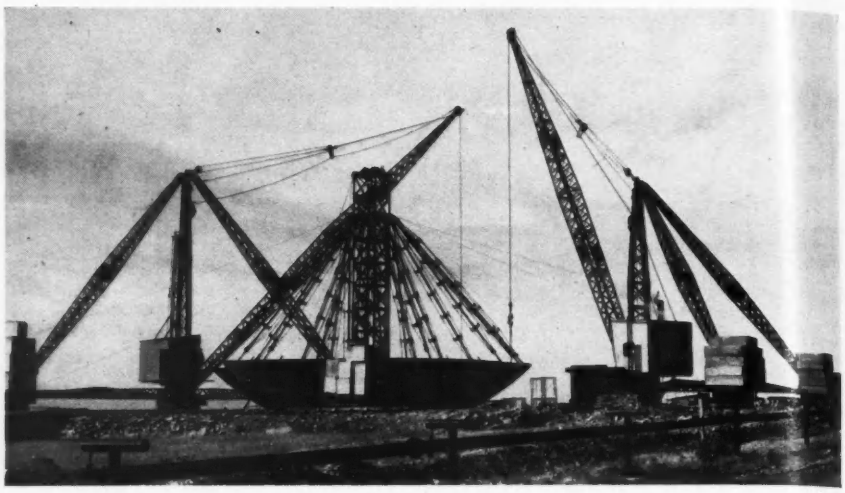
Progress made during 1956 on the East Middlesex main drainage was such that operation of the first stage of the Deephams sewage treatment plant is expected in the spring of this year. The complete plant will ultimately serve a large drainage district extending over East Middlesex and adjoining areas in Hertfordshire and Essex, with a population of about 800,000. The first stage is intended to relieve overloaded sewage works in the Lee Valley. Work in progress in 1956 included completion of the Lee Valley low-level sewer (which was built partly in tunnel, and runs from Cheshunt to Deephams works, where its diameter is 5ft 6in), further progress on the Cuffley Brook sewer, and a start on the Tottenham low-level sewer. The latter will be built mainly in tunnel ; about two-thirds of a mile of one of its branch sewers—a 39in diameter concrete pipe sewer in heading—was built during the year. The illustration (right) shows the aeration tanks and final settling tanks for one-quarter of the complete plant at Deephams. These are in fact the stage I tanks, and will be operated this year with their associated permanent and temporary works. Storm water tanks had previously been built and some of them will be used for primary sedimentation during first stage operation

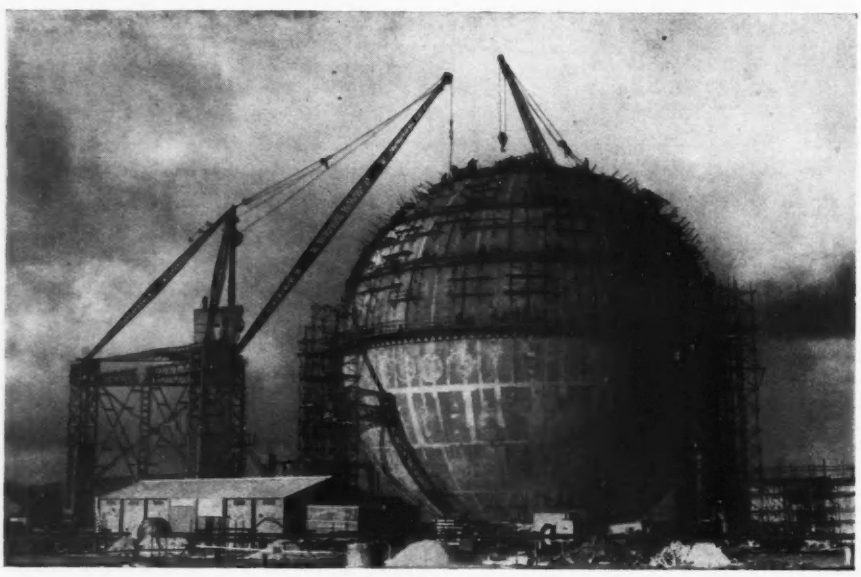


Primary sludge digestion tanks for the complete plant were under construction during 1956, and are shown on the left. These eight tanks have a total capacity of 1·32 million cubic feet. They are of reinforced concrete, about 70ft in diameter, with 30 deg. hopper bottoms and floating gasholder roofs. The arrangement of pipework at each tank aims at operational flexibility in recirculating the digested sludge, and is arranged through two pump chambers, each at the centre of a group of four tanks. Sludge will be digested by withdrawing it at a constant rate and passing it through external heat exchangers where the heaters will be fired by the sludge gas. Two heat exchangers were erected by the end of the year. During operation of stage I of the plant, digested sludge will be pumped to land for ploughing in. The stage I works also include a temporary pumping station at the end of the Lee Valley sewer. It is about 38ft deep and contains two 18in diameter sewage pumps, each driven by a 125 h.p. variable-speed motor and capable of discharging about 6500 g.p.m. Constant velocity grit channels and a "Comminuter" are also provided for stage I, and a temporary settled sewage pumping station, with two 18in, 35 h.p. pumps, will convey effluent from the primary tanks to the aeration tanks. Two blowers, each for 4000 cubic feet per minute of free air and driven by a 190 h.p. motor, will be operated from a temporary compressor house. The consulting engineers responsible for design and construction of the East Middlesex main drainage are Messrs. J. D. and D. M. Watson. Main contractors are as follows : sludge digestion tanks and other stage I works, Holland & Hannen and Cubitts, Ltd.; aeration and final tanks (stage I), Marples, Ridgway and Partners, Ltd.; storm water tanks, W. and C. French, Ltd.; sewers, William Moss and Sons, Ltd., Edward H. Jackson, Ltd., and Howard Farrow, Ltd. A contract is now in hand for the primary sedimentation tanks, aeration tanks, and final settling tanks for the complete plant ; the contractor is William Moss and Sons, Ltd., and the work is scheduled for completion in 1959. The value of works already completed and contracts now let is approximately £3·8 million

# NUCLEAR RESEARCH REACTORS

Although the fast reactor which is being built at Dounreay, Scotland, is not, strictly speaking, a research reactor, it has been included on this page because the scheme is essentially experimental. Its purpose is to provide the engineering experience necessary to enable the fast reactor to be developed for industrial power generation, with the prospect of using the uranium fuel much more efficiently than in reactors based on thermal fission. The reactor will consist of a cylindrical core, 2ft diameter by 2ft long, contained in a stainless steel pot, through which enough coolant (liquid sodium/potassium) can be pumped to remove 60MW of heat. Heat from the primary coolant will be given up to a secondary coolant in heat exchangers installed around a neutron shield surrounding the reactor pot. A concrete biological shield will enclose the pot and the primary/secondary heat exchangers. For safety reasons the reactor in its biological shield will be contained in a fabricated steel sphere 135ft in diameter and about 1in thick, shown here in two stages of construction



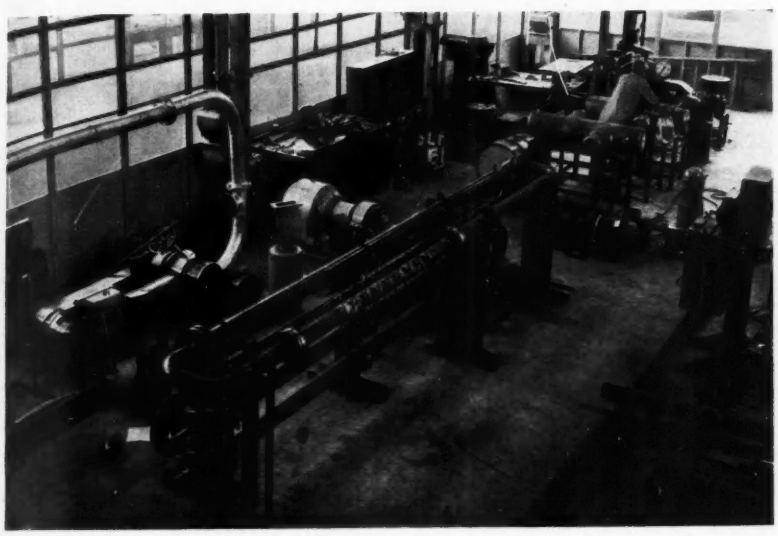


The secondary heat exchangers and the associated steam-raising plant and auxiliaries will be installed outside the steel sphere. This sphere is designed to contain any fission products that might escape from the core. The sphere is also designed for protection against fire—a risk inherent in the use of liquid metal in both the primary and the secondary coolant circuits. The sphere will contain about 13 tons of oxygen and it is calculated that in the worst conditions envisaged the air could reach a maximum temperature of 340 deg. Cent. and a pressure of 16 lb per square inch. In addition, the sphere is designed to withstand the external pressure, about 5 lb per square inch, that would eventually arise after the temperature inside the shell had fallen, leaving a partial vacuum. The effectiveness of the sphere under such conditions depends upon heat transfer, and the shell is therefore unlagged. As shown in the illustration, the sphere has been completed except the crown plate, leaving an aperture through which the plant can be lifted in

Two new research reactors went into service at the Atomic Energy Research Establishment, Harwell, during 1956. One, known as "Lido," is a "swimming pool" reactor with a peak neutron flux of $10^{12}$ thermal neutrons per square centimetre per second and a maximum power output of 100kW, and will be used mainly for shielding studies. The second, known as "Dido," is a more powerful reactor, with a neutron flux of $10^{14}$ neutrons per square centimetre per second and a heat output of 10MW, as described in our issue of December 7. In "Dido" the moderator is heavy water and the fuel is enriched uranium. The reactor is intended for isotope production, neutron physics, and nuclear reactor materials studies. Its main interest to the engineer is that it has holes for loop tests, whereby the behaviour of fuel elements and coolant systems under irradiation can be studied under dynamic conditions. The reactor core is enclosed in an octagonal reinforced concrete biological shield, which can be seen on the right of our illustration; on the left is the charging flask. To contain any fission products that may be released in the unlikely event of a fault, the reactor is enclosed in a steel shell, the wall of which is lined internally with glass fibre to provide thermal insulation. The heavy water and helium pumping installations are below the reactor and the other auxiliaries, including the secondary coolant (ordinary water) and the air conditioning plant, are outside the steel shell, which has air-lock double doors

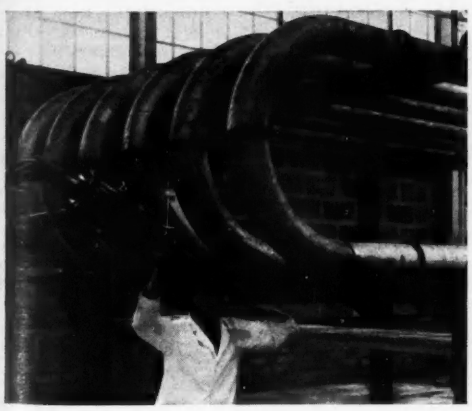
# INDUSTRIAL NUCLEAR ENGINEERING DEVELOPMENTS

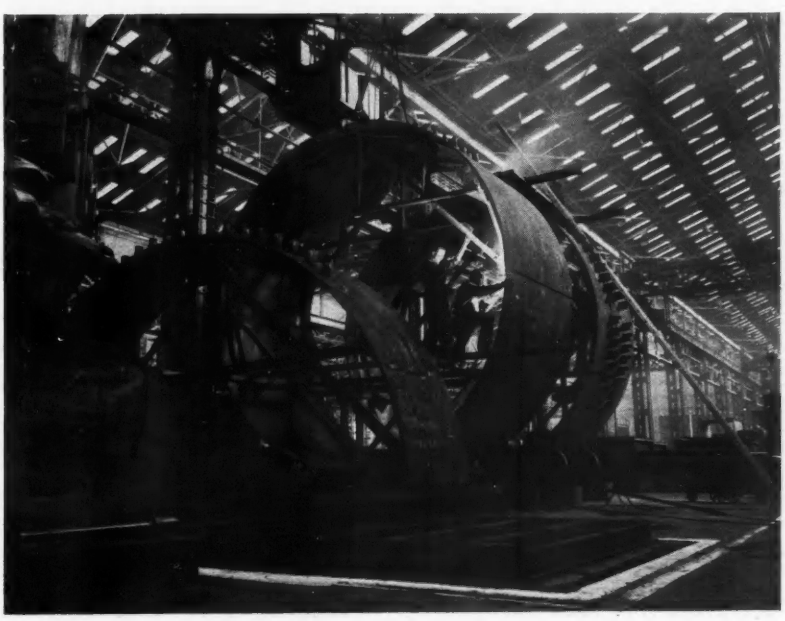
Some of the activities of the British industrial groups which have been formed to participate in the development of nuclear power are illustrated here. In the first illustration we show part of the heat transfer laboratory of the G.E.C.-Simon-Carves Atomic Energy Group, at Erith. On the left of the picture is a heat transfer test rig for heat exchanger tubes; draught losses can also be measured, and the effectiveness of several forms of finning have been compared on this rig. In the background (right) of the illustration is a pressurised $CO_2$ test rig for work on the heat transfer characteristics of fuel cans at pressures up to 200 lb per square inch. In this installation heat is applied via a stainless steel element inside a dummy fuel can and is transferred to $CO_2$ gas circulated along the outer surface of the can. In the same laboratory there is equipment for the testing of viscous oil seals for sealing gas at the glands of blower shafts



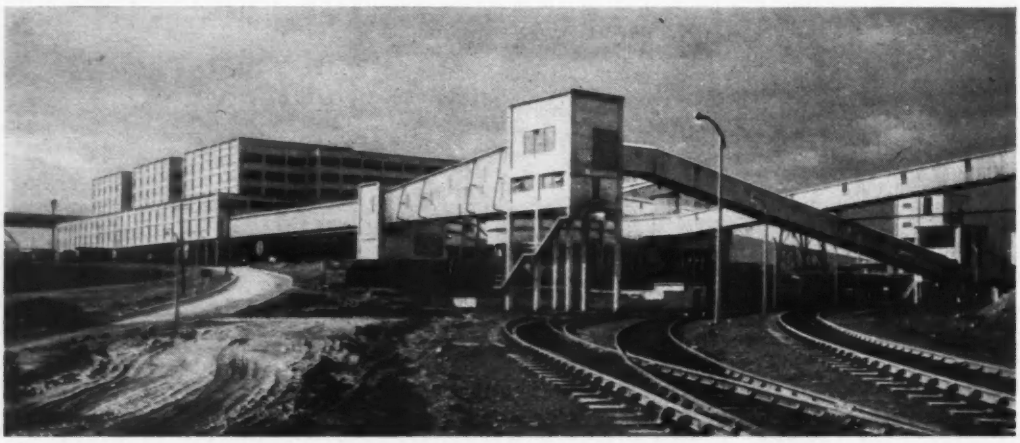
Our second illustration shows part of another heat transfer laboratory, that of Babcock and Wilcox, Ltd., at Renfrew. In the apparatus illustrated on the left, the dummy fuel can is mounted inside a steel pipe through which $CO_2$ gas is circulated under pressure. Heat is generated in a flat strip spiral element insulated from the inside of the can by a thin film of aluminium oxide, an arrangement which permits a loading of up to 15kW per foot run. Measurements can be made of gas flows, pressures, temperatures, and electrical input to the heater elements. The illustration below shows sections of the shell of one of the steam-raising towers for the Chapel Cross station of the U.K. Atomic Energy Authority being manufactured in the Renfrew works of Babcock and Wilcox, Ltd. The heat exchanger installations are practically identical with those for Calder Hall, the shells of the towers being finally fabricated on site from six cylindrical sections and top and bottom domed ends. These sections are fabricated in the works from plates which have previously been tested ultrasonically for flaws, then shot blasted and bent to cylindrical form. The strutted framework which can be seen in the illustration prevents distortion of the cylindrical sections during fabrication. Thermal sleeves are provided in these cylindrical sections to allow the connections of the tubular heat exchanger banks to pass through the shell to the headers and steam drums outside the tower

A section of one of the main heat exchanger banks for the Dounreay fast reactor is shown below, during manufacture at the works of John Thompson, Ltd., Wolverhampton, Staffs. The tubular heat exchanger is double walled. Primary coolant is circulated through the inner tube and secondary coolant through the outer tube. In both, the fluid is sodium-potassium and the heat exchangers are of stainless steel. Rigorous controls over fabrication of the heat exchangers include gas-leak detection tests and radiographic inspection



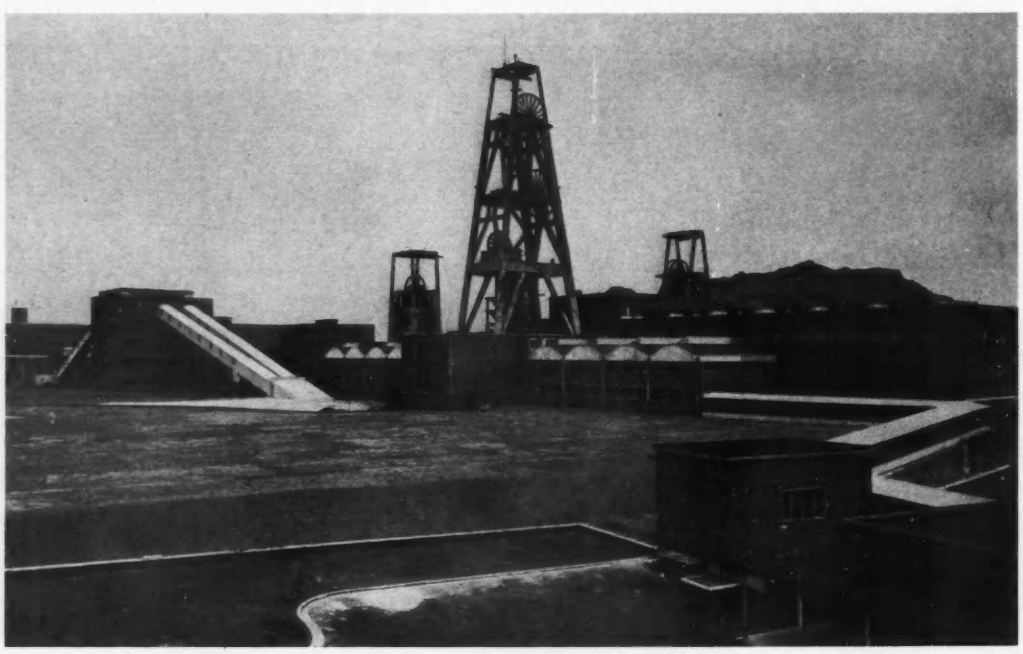


# NATIONAL COAL BOARD'S MODERNISATION PROGRAMME



A number of programmes of reorganisation and modernisation have been in progress at the collieries of the National Coal Board for some years. Coal preparation has formed an important part of these plans and on the left there can be seen the new 1320-tons-an-hour capacity coal cleaning plant installed at Manvers Main Colliery, Yorkshire, which came into operation in August, 1956. It is the biggest plant in the country and deals with the output of four collieries

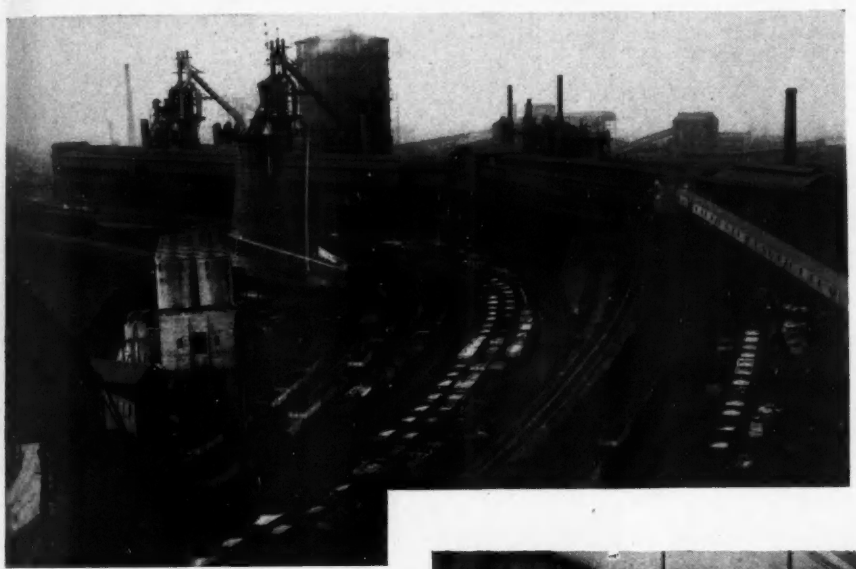
Mardy Colliery, South Wales, illustrated on the right, is about 20 miles north of Cardiff and at the far end of the "Little Rhondda" valley. This colliery has been completely rebuilt and is scheduled to reach an output of 4000 tons a day by the early 1960s. New roadways more than 2 miles long and driven at three different levels, now connect this pit with Bwllfa Colliery, in the neighbouring valley, and all the coal is being wound at Mardy. The estimated coal reserves in this area are 100 million tons, or enough to last 100 years



An extensive scheme of reorganisation and modernisation has also just been completed at Bold Colliery, near St. Helens, illustrated on the left. Under this plan all the original surface buildings have been replaced by modern structures and equipment, steam power for winding purposes has been replaced by electric drives, and a new coal preparation plant installed. An important part of the overall plan of modernisation has been the construction of a new power station by the Central Electricity Authority on a site immediately adjoining the colliery. The coal supply for this station is taken directly by belt conveyor from the coal preparation plant. There are workable reserves of 61,000,000 tons of coal in this area, and the planned output is 840,000 saleable tons a year

# IRON AND STEEL WORKS

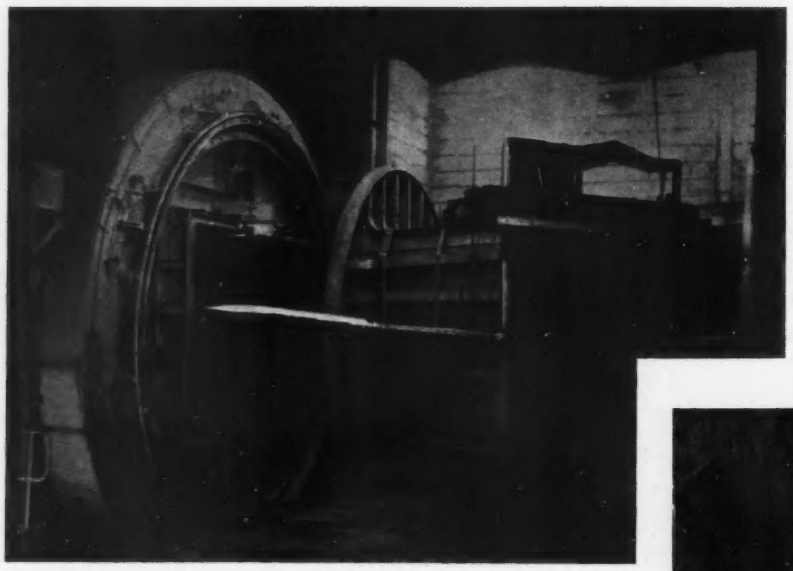
Further progress was made last year towards the completion of the British iron and steel industry's second post-war programme of development and expansion. The work illustrated on this page is representative of that which is going on in all the steel making districts of Great Britain. These two illustrations (left) show work recently completed at the Cleveland plant of Dorman, Long and Co., Ltd. The first illustration is of the new coke oven plant, known as the South Bank coke ovens. The plant started production at the end of November. It consists of 150 Simon-Carves underjet ovens, in two batteries of seventy-five, and is designed for a production of 15,000 tons of graded coke a week and 2000 tons of coke smalls by the carbonisation of 25,000 tons of Durham coking coal. This project has involved the installation of a coal preparation plant for the systematic blending of coals, and there is provision for a reserve ground stock of 100,000 tons of coal. The daily output of by-products from the new plant is expected to be 40,000,000 cubic feet of gas, 140 tons of tar, 11,000 gallons of benzole and 40 tons of sulphate of ammonia



The second illustration shows the new blast-furnaces which have been built at Clay Lane, adjacent to the Cleveland works. There are two furnaces, which together will produce 750,000 tons of iron a year. With hearth diameters of 27ft 6in the furnaces are the largest on the North East Coast. The new plant replaces four small furnaces, which are soon to be dismantled. Our illustration shows part of the conveyor system for feeding the furnace bunkers with prepared materials, and also the 5,000,000 cubic foot gasholder which has been erected. The first of the new furnaces was tapped at the beginning of December, and it is hoped that the second will be in operation in the very near future

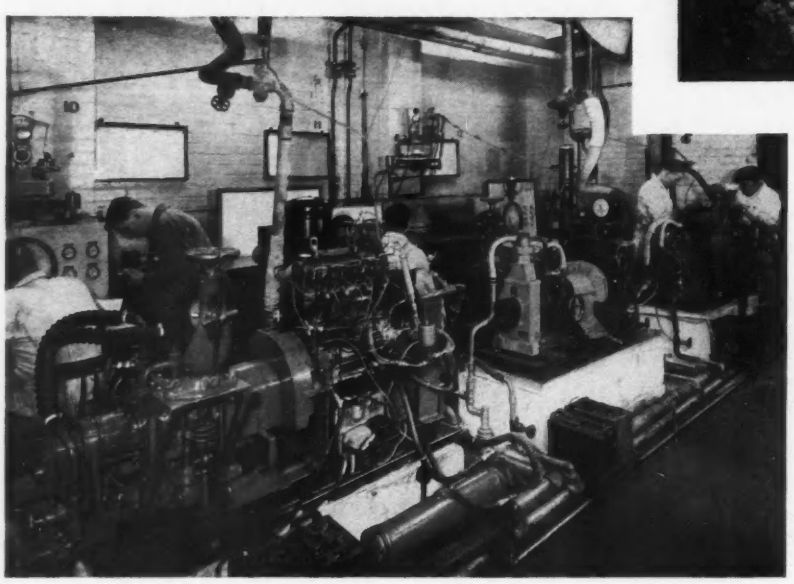
One of the steel works development schemes in South Wales is that at the Ebbw Vale works of Richard Thomas and Baldwins, Ltd. Early last year, there came into production at Ebbw Vale a new five-stand tandem cold strip mill, designed to operate at a maximum speed of 5000ft a minute. The mill, the entry side of which is illustrated here, was built by Davy and United Engineering Company, Ltd., and is said to be the fastest cold tandem mill at present operating in this country. In full production it is capable of rolling about 10,000 tons of steel strip a week. The strip [rolled is up to 38in wide, the ingoing gauge being up to 0·140in and the output gauge down to a minimum of 0·006in. The strip can be handled in coils weighing as much as 36,000 lb

# RESEARCH AND TESTING



The 9ft by 8ft tunnel of the Aircraft Research Association runs between Mach numbers of 0·6 and 1·3, with the possibility of attaining 1·6 if the installed power is increased. The walls of the working section are perforated, and for the higher transonic Mach numbers an auxiliary compressor is used to return bled air to the circuit; diffuser suction will take the section up to Mach 1, but is extravagant on power. The nozzle has a variable geometry, and the divergence of the walls is also adjustable. A removable length downstream of the working section allows models to be introduced ready for test on a cart which includes parts of the tunnel floor and ceiling. Force and moment measurement is by strain gauge in the head of the sting. The sting passes through a pivot in the forward edge of the support fairing; as this forward edge is moved up and down, the linkage above the cart moves the overhung rear end of the sting, so that incidence varies without the model rising or falling. Readings recorded on punched cards are automatically reduced to coefficient form. The installed motors total over 40,000 h.p., and the working medium is cooled by a water flow of 6000 gallons per minute

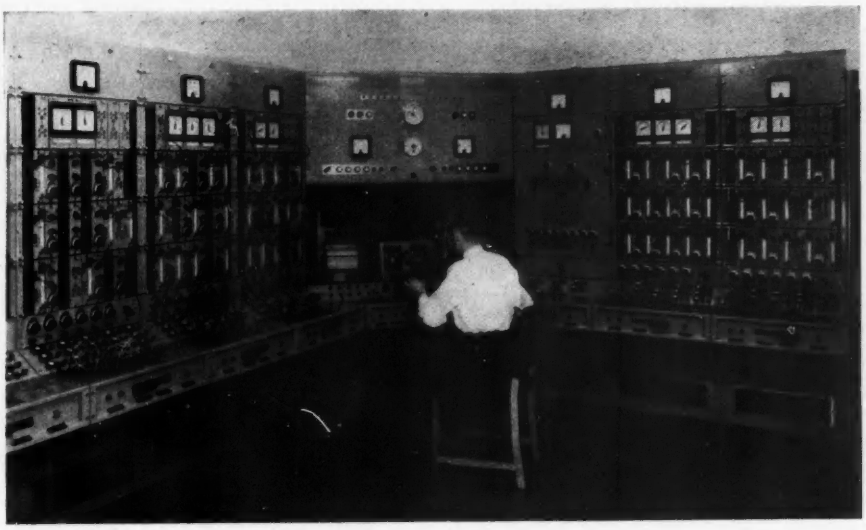
Wirksworth testing station has been laid out by Stewarts and Lloyds for testing—at full scale—transmission line towers and similar tall structures. It makes use of a unique natural site, which is, in fact, a disused quarry, and, as can be seen from the illustration on the right, horizontal loads can be applied to the top of the tower from anchor bolts grouted into the rock faces of the quarry. By making use of rising ground above the quarry, it is expected that structures up to 200ft in height can be tested. Measuring instruments for loads and deflections have been developed specially for use at the station, and the control and instrumentation is noteworthy. A tower built of tubular steel, 130ft in height, and intended for the 275kV "supergrid," is shown under test



The E.R.A. suspension test vehicle is used to gain objective measurements of road vehicle steering and suspension behaviour. The use of the E.R.A. equipment for complete vehicle studies is illustrated above left; a Renault "Dauphine" is shown coupled to comprehensive electronic equipment within the parent recording vehicle by a cable and swinging arm. The test car is separately driven and can swerve up to the limit of adhesion within a 30ft wide track beside the recording vehicle, which has a maximum speed of 60 m.p.h. The steering response characteristics of the car may be studied under applied transient or cyclical steering displacements, the resultant lateral, yawing and rolling motion histories being used to determine the general stability and response rate values. Suspension behaviour may be examined in the transient response of the sprung and unsprung masses when driven over known road deformations.

The heavily loaded and highly stressed fuel systems of high-speed diesel engines require intense development to match them to individual engines, and the C.A.V. test beds (left) include eighteen hydraulic and electric dynamometers from 350 h.p. to 20 h.p. In the foreground a distributor fuel pump, recently introduced to this country after extensive service in U.S.A., is seen in action. The established jerk pumps are on test on other beds

# INDUSTRIAL ELECTRONIC EQUIPMENT

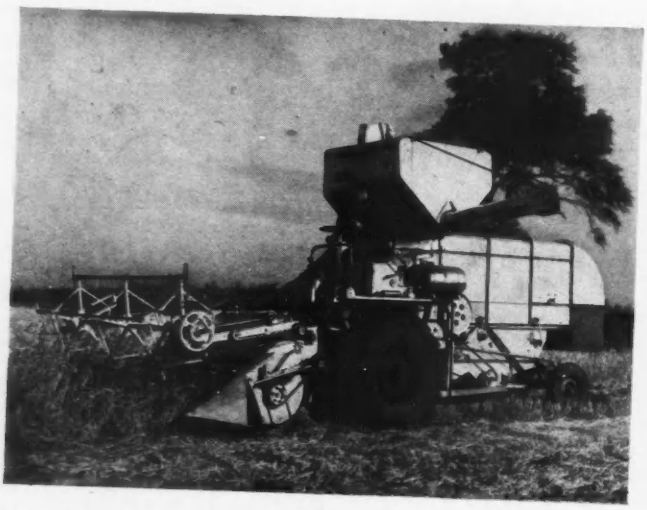


An analogue computer made by Elliott Brothers (London), Ltd., is being used by the G.E.C.–Simon-Carves Atomic Energy Group to study transient phenomena in reactors and other components of nuclear power stations. This analogue machine, part of which can be seen in the illustration on the right, consists of a control cabinet and seven computing cabinets. One of the cabinets simulates the equations of reactor kinetics, with controls which can be preset according to the characteristics of any particular fissile material. The parameters that can be inserted include step changes in reactivity and changes that depend on temperature, poisoning and other quantities. On the remaining six cabinets other parts of the power station, such as heat exchangers, turbines and alternators, can be simulated. There are sufficient amplifier units to permit representation of a large number of simultaneous equations. A transit time-lag simulator permits the inclusion of the effect of coolant transport from reactor to heat exchanger; this time lag is continuously variable and can be controlled from the output of an amplifier unit. Two independent problems may be solved simultaneously

Another analogue computer is shown on the left. It is installed at the Short Brothers and Harland, Ltd., technical department at Belfast, where three coupled computers are being used to simulate an aircraft take-off problem in real time in association with a handling simulator also developed by Shorts. The problem being studied is that of an aircraft take-off run from "brakes off" to the fully airborne condition involving varying velocity and coefficient switching as the wheels leave the ground. The computing units are all standard production items, but for the first time the new automatic time switching unit has been used in conjunction with the usual linear units, multipliers and function generators. The aircraft behaviour is presented to the pilot on a standard "blind flying panel" and the object of the study is to assess his ability to control quickly developing pitching moments and maintain the aircraft at a suitable take-off attitude. Records of the pilot's reaction and aircraft response are taken on various pen recordings and thus the range of pilot reaction can be taken into account at the design stage

The left-hand illustration above shows a mass spectrometer made by Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, for the U.K. Atomic Energy Research Establishment, Harwell. Another instrument which reduces the time required for making analyses (of samples of stainless steel, in this case) is illustrated on the right. It is a "quantometer," made by Applied Research Laboratories, of Lausanne, Switzerland, and is installed in an air-conditioned laboratory at the Stocksbridge works of Samuel Fox and Co., Ltd. The quantometer consists of a multi-source unit, a spectrometer and a recording console and is designed for the determination of seventeen elements, from a trace up to 30 per cent. Its potentialities are illustrated by the fact that it can, for example, yield an analysis for manganese, nickel, chromium, molybdenum and copper in a sample of steel within fifteen minutes, compared with one hour for orthodox analysis

# AGRICULTURAL MACHINERY



Recent developments in British agricultural machinery include improved designs of grain and root harvesters. These illustrations show (left) a self-propelled combine-harvester for grain crops, and (right) a tractor-operated sugar beet harvesting machine. The combine-harvester has been produced by Ransomes, Sims and Jefferies, Ltd. ; its power is provided by a 57 b.h.p. diesel engine, and the cutting width of the machine is 12ft. This harvester, it is claimed, can deliver up to 6 tons of grain an hour. The sugar beet harvester is built by John Salmon Engineering Company, Ltd., its function being to top, lift, and clean the beet crop and finally elevate it to a trailer alongside. The topping mechanism is situated at the side of the machine, which is driven from the tractor power take-off

The hay and straw baler illustrated here is hauled by a tractor, and its mechanism is operated by a 22 b.h.p. diesel engine. This machine was introduced last summer by International Harvester Company of Great Britain, Ltd. The machine can produce 15in by 19in bales, in lengths varying between 36in and 40in, and weighing from 80 lb to 125 lb. The material is sliced as it enters the baling chamber by a knife mounted on the plunger, and, as each bale is formed, a metering wheel, situated at the side of the baling chamber, turns with the advancing bale and measures its length. The metering wheel is coupled to a trip finger by two bevel gears, and as a bale reaches the preselected length, the trip finger engages a release mechanism, an action which enables the tying needles and knotters to function

Another example of a combine-harvester is illustrated here (left). This machine is built by Massey-Harris-Ferguson, Ltd., and is mounted on a Ferguson tractor. In designing the harvester the requirements of smaller farms have been kept particularly in mind. The cutting width is 7ft 6in, and by using the tractor's hydraulic lift, the height of cut can be varied between 2in and 32in. The harvester is driven from the power take-off shaft of the tractor on which it is mounted. The dragline ditch cleaning machine illustrated (right) is made by Whitlock Bros., Ltd. The machine is mounted on a "County" crawler tractor, and the ditch cleaning attachment consists of a double drum winch, driven from the power take-off shaft through reduction gearing, each winch being controlled by friction clutch and brake assemblies which are operated by the tractor driver. Incidentally, the ditch cleaner boom, when the bucket is removed, can be used as an offset crane capable of handling loads of up to 15 cwt

# The Royal Navy, 1956

BY OUR NAVAL CORRESPONDENT

(No. II—*Concluded from page* 15, *January* 4)

THERE are at present twenty front-line squadrons earmarked for our fast carriers. Seven of them are equipped with "Sea Hawks," three with "Sea Venoms"—both versatile and very fine aircraft within their straight-wing, subsonic limitations—five with twin-Mamba Fairey "Gannets" for anti-submarine work, two with "Wyverns" and two with "Whirlwind" helicopters. The remaining squadron is made up of four flights of American Early Warning Skyraiders. There also are eleven squadrons manned by the Royal Naval Volunteer Reserve. The "Gannets" (Fig. 9) have fully come up to expectation as first-rate hunter/killer anti-submarine aircraft, with a large endurance. They have been operating at sea continuously over a lengthy period and have proved easy to maintain in relation to the complexity of engines and electronics. Another and smaller anti-submarine aircraft is the Short Brothers and Harland "Seamew," which has relatively low landing and take-off speeds and should be specially suitable for operating from escort and other small carriers. First deliveries are apparently earmarked for Coastal Command and for the Royal Naval Volunteer Squadrons. But they can be quickly and cheaply built in the event of our having to improvise a number of escort carriers from merchant ships for convoy protection duties. Many naval air experts consider that the small Folland "Gnat" should also have been taken up by the Fleet Air Arm for trade protection duties. This light jet fighter has a high performance, is easy to handle and maintain and can be operated in a carrier's lift without the necessity of wing folding. With long-range tanks it has a patrol duration of about two hours. The eleven R.N.V.R. squadrons are equipped mainly with "Attackers," "Sea Hawks," "Gannets" and "Avengers." and opportunity was taken in the summer before the "Bulwark" left for the Mediterranean to give the "Attacker" and "Sea Hawk" pilots their first deck landing training with jet aircraft.

Increasing importance is being attached to the helicopter for anti-submarine work, and it may well be that it will in due course replace the "Gannet" and other fixed-wing anti-submarine aircraft. Trials with merchant ships have proved that they can take off and land on successfully in moderate weather, and with greater experience in maintenance there is no reason why merchant ships should not operate their own helicopters as a protection against submarines. The Navy's first turbine-engined helicopter, the Westland "Wessex," powered by the Napier "Gazelle," is now in production for A.S. duties—cruising speed 110 knots, range with full load 380 miles. Of the two existing front-line squadrons, one is earmarked for anti-submarine duties and the other is still in Malaya operating against the terrorists. Both are equipped with Westland "Whirlwinds" (Fig. 10), later versions of which will be powered with the Alvis "Leonides Major" engine to give them greater load-carrying capacity and improved ceiling. Successful trials have also been carried out with "Whirlwinds," fitted with inflatable pontoons, in alighting on and taking off from the water. Sweeping certain of mines which still present problems for safe sweeping by surface vessels is another role visualised for the helicopter, a role which may well intensify the controversy over the future control of maritime air forces.

It is interesting also to record that in the landings at Port Said on November 5-6 carrier-borne helicopters, for the first time in British history, were used for operational landings and were able to put ashore some 500 men of the Royal Marine Commandos within ninety minutes. The two training squadron carriers "Ocean" and "Theseus," with operational helicopters aboard, ran shuttle services with water, food and medical supplies for the Allied troops.

### Submarine and Anti-Submarine

Until 1945 the submarine, which, in both world wars nearly brought this country to her knees, remained as originally designed, a surface vessel capable of submerging but with her mobility when submerged reduced to little more than that of a floating mine. With a motive power dependent on electric motors and storage batteries, her patrolling speed was between 1½ and 2 knots, with a top speed of 10 knots for less than an hour, when her batteries were exhausted. Obliged to come to the surface at night to recharge her batteries, she was then a prey to any hostile patrol vessel or aircraft in the area. Towards the end of World War II, however, the Germans had built, and were operating submarines which, with good streamlining and greatly increased battery power, had a top speed of 17 knots—again, of course, lasting less than an hour, when the batteries were exhausted. They were also fitted with a snort, or breathing pipe, to supply air to the diesel engines, which enabled them to remain submerged when charging batteries or making a passage at economical speed. Britain and the United States have now similarly reconstructed many of their existing submarines in this manner and are also building new vessels with the same characteristics. But the Germans realised that this type of submarine could only be a stopgap and by the end of the war had ordered 100 vessels of 850 tons, which would have met the essential requirement submerged of modern submarines. They must be able to proceed submerged fast enough and for a sufficiently long period, to evade anti-submarine vessels, and when faced with enemy aircraft patrols, to continue at high speed for at least 100 miles to intercept a reported target. The Germans believed that their new submarine met this requirement, with an endurace and speed of 160 miles at 25 knots. The engines were of a then entirely novel design, employing hydrogen peroxide. The peroxide, stored in the ballast tanks, was pumped to a catalysis chamber, where it decomposed, the oxygen going to a combustion chamber where ordinary light diesel oil was supplied as a fuel. The products of combustion drove a gas turbine. A condenser condensed out the steam and a compressor compressed the $CO_2$ and pumped it overboard. Carbon dioxide is soluble in water and thus leaves no track.

Exhaustive trials were carried out on the German engine after the war, both by Britain and the United States, but by 1950, mainly due to the persistence of an American naval officer (Captain, now Admiral Rickover), the Americans decided to abandon this engine in favour of atomic power. Apart from the risk of fire and explosion from the decomposition of $H_2O_2$ in the hydrogen peroxide unit, the submerged endurance is, of course, limited by the quantity carried. And Captain Rickover insisted that the United States Navy must have a submarine which "could proceed round the world submerged at high speed." The Royal Navy, however, continued its investigations into the German engine and has now built two submarines—the "Explorer" (see page 30 *ante*) and "Excalibur" with a propulsion unit which appears to be very similar. These two submarines were built ostensibly for the purpose of training anti-submarine personnel in dealing with high-submerged-speed submarines. But as the result of the experience gained from the United States atomic-powered vessels we are now also designing an atomic plant as the motive power for our future submarines. It is greatly to be hoped, however, that we shall give much further consideration to the subject, and also fully exploit the capabilities of the "Explorer" before finally committing ourselves to a costly atomic power plant for submarines, in view of the much greater value it would have for our surface ships. The medium-sized conventional submarine has a range of 10,000 miles (either on the surface or using the snort submerged) at economical speed. Moreover, owing to the "hydrophone effect" given off by a fast running engine, high speed submerged cannot

**Fig. 9—The Fairey "Gannet," the Navy's anti-submarine aircraft**

be used when attacking. Also, a large submarine—the United States vessels are well over 3000 tons—provide a much easier target for detection by asdics. These are important considerations to be weighed against the somewhat dubious advantage of being able " to proceed round the world at high speed submerged " and the more obvious advantage of requiring fewer submarines " in the pipeline " to carry out a given patrol. For a Power with the surface command of the sea it is surely more important for underwater vessels to have high submerged speed for a few hours than unlimited submerged endurance.

Britain has now sixty-one effective submarines of the conventional type, including four midget or " X " class vessels, and has under construction a further eight, well streamlined, and with increased battery power. Two of these new submarines—the " Porpoise " (Fig. 11) and the " Rorqual "—have already been launched. They are large submarines—295ft in length, compared with the 225ft " Explorer," which has now been in commission for over six months. It is curious that, while the U.S. Navy has eight nuclear-powered submarines built, building or ordered (the present target is fifteen in all of this type), there is no firm information that the Soviet Navy is building underwater vessels either with an atomic power plant or with engines using hydrogen peroxide. All the indications are that the Russian naval authorities are going in for the cruiser-submarine, streamlined and with large battery power and fitted with the snort for commerce warfare. The First Sea Lord recently credited the Soviet Navy with 350 modern submarines —compare this number with the twenty-six ocean-going submarines in the German Navy in 1939—and the Admiralty estimates that there will soon be 500 Russian submarines, all in commission. The larger, cruiser type vessels, by using the snort, could make passages submerged in known danger areas, but would operate virtually as surface raiders while preying upon distant trade routes. It is, however, the minelaying submarine and the guided missile firing submarine which now present the most serious dangers. Since the rearmament programme began, we have built over 150 minesweepers of a new type to deal with acoustic and other influence mines, and another sixty are building. But we shall need patrol craft of all kinds—aircraft helicopters, frigates and patrol vessels—to cope with the submarine which could give the widest possible berth to our patrol craft and fire guided missiles with nuclear warheads from positions 100 to 200 miles from our coasts. The Americans already have submarines equipped to launch guided flying bombs—an operation which requires little professional skill or good judgment on the part of their commanding officers. On the other hand, any submarine which deliberately comes within range of our detecting devices stands a poor chance

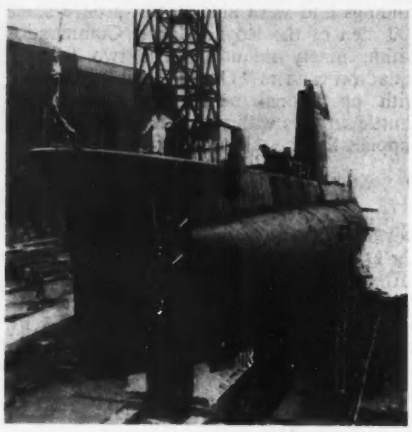


**Fig. 11—H.M.S. " Porpoise," one of Britain's new 1500-ton conventional submarines with diesel-electric propulsion**

of attacking or even of escaping. The effectiveness of our measures for locating and destroying submarines has enormously improved since the war. The snort can now be detected by radar from surface craft or aircraft. Magnetic airborne detection equipment detects the presence of a submerged submarine from the local change her hull makes in the earth's magnetic field. The transmitted recordings from a battery of sonobuoys dropped from an aircraft near the submarine's position enable her underwater track to be plotted. Dipping asdics are also of particular value when used by helicopters. All these new devices have been developed concurrently with a marked increase in the efficiency and range of the asdic installation and in the variety, power, accuracy and range of our anti-submarine weapons.

**Fig. 10—Westland " Whirlwinds " landing on H.M.S. " Eagle "**

### Research and Development

When presenting the current year's Navy Estimates, the First Lord announced that a larger financial provision would be necessary for the research programme which would be modified and concentrated mainly on special fields. Particular attention is now being devoted to the development of guided weapons and nuclear propulsion for the Navy and to research into valves and electronics for the three Services. Britain started late in the development of guided missiles, but as long ago as 1953 it was realised that a special ship would be required for carrying out the sea trials of the kinds of missiles intended for the use of the Fleet. A maintenance vessel—H.M.S. " Girdle Ness "—was selected and reconstructed in Devonport Dockyard to try out the anti-aircraft guided missile then under development. A ship of 10,000 tons, built in Canada as a landing craft maintenance vessel, she was commissioned for her new role last July. She has the appearance of a large square superstructure superimposed on which is a tangle of radar masts and aerials of every variety. The guided weapon equipment consists of radars, displays and communications equipment to enable a target to be selected and to control the missiles in flight; magazines and handling gear for stowing and transporting the missiles, and finally a triple mounting launcher. The missile launcher, which is immediately before the bridge, can be trained and elevated and is fitted with tracks up which the missiles travel. The missiles come from the magazines on rails and are rolled through flash-tight doors between decks to the launching site. Below each of the ramps of the launcher is a flash-tight hatch through which the missiles are raised by hydraulic power. The radar equipment in the stern gives bearings, heights and long-range warning, while on the foremast are the conventional navigational radar and the radar which automatically follows the target and along which the missile is made to fly.

Concurrently with the guided missile trials, practical work has now been started in this country on planning a marine nuclear plant to be installed in the first instance in a submarine. Almost a year ago Vickers-Armstrongs, Ltd., announced that a new group for atomic work had been formed consisting of Vickers-Armstrongs, Ltd., Rolls-Royce, Ltd., and Foster Wheeler, Ltd. The research reactor Lido, which will assist in the development of a nuclear propulsion unit for submarines, started operating at Harwell in September. Further trials have also been carried out during the summer in the trials cruiser H.M.S. " Cumberland " of automatic equipment to remove personnel from exposure to radiation dangers after an atomic explosion. Successful results have been obtained with the remote control of main engine throttles and with automatic temperature controls for oil fuel heaters. A closed circuit television display of boiler water level is also being studied. Among other trials carried out by the " Cumberland " which were interrupted by the vessel having to take troops to the Mediterranean—were the tests of two new gun control systems, both of which automatically train and aim at a target by radar, and of the new 6in turrets intended for the three " Tiger " class ships (Fig. 12). Opportunity was also taken to carry out trials on a wide variety of projects designed to save weight or reduce mainten-

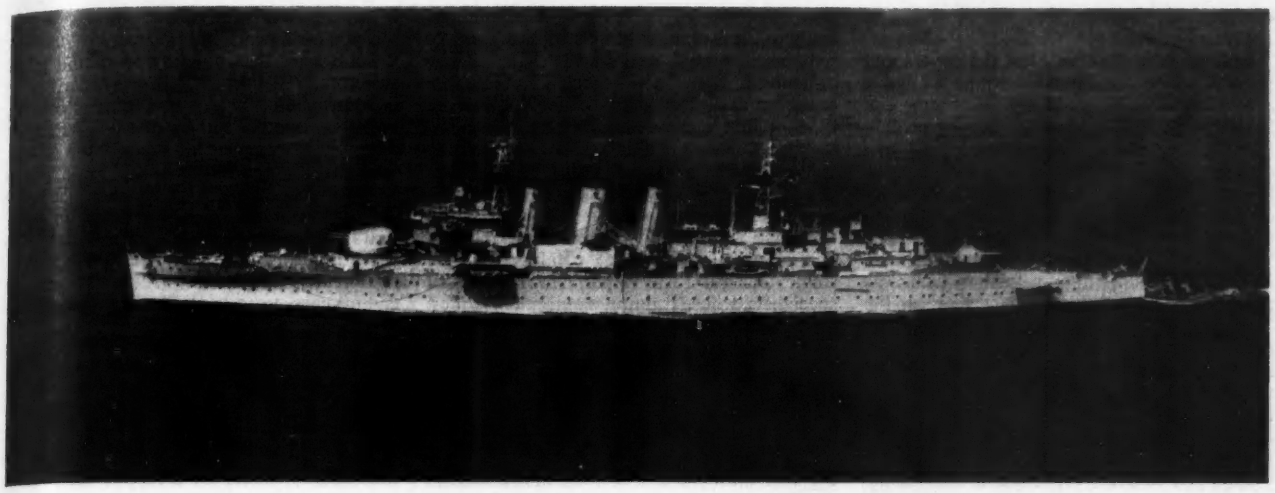


Fig. 12—H.M.S. " Cumberland," Britain's trials cruiser, with prototype of twin 6in turret for " Tiger " class cruisers

ance in a ship. These included tests of a new type of glass fibre ventilators ; laminated deck planking ; door clips, guard rails and awning stanchions of sold stainless steel ; a 25ft glass fibre motor boat and a new 16ft " vee " drive, fast " Skimmer " with a supercharged diesel and a speed of 15 knots. Orders were placed during the past year for prototype propulsion machinery installations of a new and revolutionary design for use in frigates and fast escort vessels. The principle employed is that of highly efficient steam turbines and gas turbines geared to the same propellor shaft, the gas turbines being used to boost the steam turbines for sustained bursts of high speed. The machinery installations were designed by Yarrow and Co., Ltd., in conjunction with the Admiralty.

Further investigation of the " one-man chamber " for escaping from submarines, described in these columns a year ago, has shown that it is inherently unreliable. It has therefore been decided that new submarines are to be fitted with the same arrangements for escaping as are now in use in existing submarines. The Davis escape apparatus, which helps to reduce the chances of $CO_2$ poisoning and " bends " is no longer employed because of the danger that results from oxygen poisoning. The escaper now uses the " free ascent " method, floating to the surface equipped with only an immersion suit. Twill trunks are let down from the escape hatches (Fig. 13) and after the compartment has been flooded sufficiently to equalise the pressure, the hatch is opened and each man escapes in turn. Without the twill trunk, the air left in the compartment would rush out and the hatch would close again owing to the sea pressure overhead becoming momentarily greater. Bottles are fitted at each end of the submarine, with a mouthpiece for each man, containing a mixture of 40 per cent oxygen and 60 per cent nitrogen, which the crew breathe while the compartment is being flooded up. Investigation has proved that this method gives the best chance of escape from depths down to 200ft. New submarines, however, will have a hatch fitted in the bow and stern to which a rescue bell can be attached by rescuers working outside the vessel. The use of this method is limited as it depends on the presence of a rescue ship with a bell, but it can be used at depths greater than 200ft.

### Dockyards and Maintenance

A net grant of £346 million was approved by Parliament for the current year's Navy Estimates—£5,500,000 more than was provided for the financial year 1955–56. The policy initiated in 1955 of increasing the proportion of the Reserve Fleet to be maintained at the highest standard of readiness is expensive, both in manpower and money. It is, however, essential under the conditions of thermal-nuclear warfare that ships should be ready for service with the minimum delay after the outbreak of war and the Admiralty is therefore concentrating on modernising, refitting and maintaining in readiness a small number of essential ships. A number of destroyers, escorts and smaller vessels have already been fully refitted, equipped with stores and manned with skeleton crews which can be rapidly augmented to bring the ships to the shortest possible notice for war. Certain other vessels have been refitted, but are not kept in such a high state of readiness. They are, nevertheless, capable of being mobilised and made ready to fight in the early stages. The best of the others have been, or will be, made available to friendly navies. The remainder will be scrapped when they reach the end of their useful lives and their equipment has been removed. Concurrently with the reorganisation of the Reserve Fleet to give the most efficient fighting force for the least cost in money and manpower, the whole supporting organisation ashore is being reviewed to ensure that it is adaptable and economical and that as much money and manpower as possible can be devoted to the sea-going fleet. The first interim report on this review was presented to Parliament in August by Lord Cilcennin—recently relieved as First Lord by Lord Hailsham—and provides for a saving of 5000 posts ashore held by uniformed personnel. The review is to cover storage, maintenance establishments, training centres, research stations and the Admiralty itself. Elementary specialist training is in future to be carried out at sea as far as possible and training ashore is being reorganised to cut out overheads and redundant establishments. The Royal Naval Barracks are also being reorganised to become mainly training centres and the new strategy has made it possible to reduce considerably the size of a number of our Fleet bases, some quite considerably. Among the more important reductions are :

Scapa naval base to be closed, Invergordon to be reduced to care and maintenance.

The gunnery schools at Chatham and Devonport Barracks to be closed and gunnery training to be concentrated in H.M.S. " Excellent " (Portsmouth) and in H.M.S. " Cambridge " (Wembury).

H.M.S. " Ceres " (School for Supply and Secretariat at Wetherby, Yorks) to be housed in the R.N. Barracks, Chatham.

H.M.S. " Raleigh " (Engineer Mechanics Training, Devonport) to be housed in Devonport Barracks.

H.M.S. " Alaunia " (Mechanical Training and Repair, Devonport) to be absorbed in H.M.S. " Sultan " (Gosport) and by the Mechanical Training Establishment, Chatham.

H.M.S. " Defiance " (Torpedo, Anti-Submarine and Electrical School, Devonport) to be closed and absorbed in other establishments.

The R.N. Air Stations at Anthorn (Cumberland) and at Fearn (near Invergordon), and the R.N. Armament Depot, Woolwich, are to be closed ; and the R.N. Cordite Factory, Holton Heath, is to be reduced to care and maintenance.

Warship maintenance is cheaper in the Royal Dockyards than by private industry mainly because the former have the specialised labour and plant needed for the complex equipment of ships of the Royal Navy. But many of our docks and refitting basins are out of date while some of the principal buildings are unsuited to modern industry. Moreover, not all the major war damage suffered by some of our dockyards has yet been made good. A modernisation plan covering capital plant and equipment was started two years ago and the first need has been to provide new shops to handle the new radio, radar and gunnery equipment. New electrical shops have been completed at Chatham, Portsmouth and Malta. New shops are well advanced at Devonport and are in hand at Rosyth. A start has also now been made at Portland and Singapore. New gunnery equipment shops are now in use at Devonport and Malta and are under construction at Chatham and Singapore. The plan provides for better premises for apprentice training, better working conditions in the shops and better shore amenities for the crews of ships refitting. A student apprentice scheme is now being introduced to augment the existing craft apprentice scheme. The students will be given a technical education as good as any in the country and will provide the main source of dockyard technical officers. The craft apprentice of merit will have the opportunity to transfer to the student class. At the same time a new entry into the Royal Corps of Naval Constructors is to be introduced to provide an additional source of professional

officers from those leaving school at 18½ to 19½ years of age.

Many of the Reserve Fleet destroyers and frigates which are intended to be available at short notice are laid up in commercial harbours and maintained largely by civilian labour after being dehumidified. A successful test was carried out in 1955 on the frigate "Eglinton" to determine the efficiency of dehumidification and other arrangements for the preservation of their vessels. The "Eglinton," however, is an old and comparatively simple ship and a further trial was therefore carried out early last year on the "Dainty," a "Daring" class ship, which had been in reserve, dehumidified at Barrow for the previous two years. This trial also was in every way satisfactory, the vessel being speedily commissioned and carrying out full sea trials and functional test of all machinery and equipment. The building of houses and flats for officers and men at the home ports under the Armed Forces Housing (Loans) Bill continues to make good progress and it is expected that some 930 married quarters will have been completed by March 31 next, as compared with 635 in the previous year. At the same time a new emphasis is being placed on living accommodation for the single man, most of which is either in the traditional barracks and which is old or out of date or in temporary wartime buildings. In May last H.M. the Queen Mother opened a new block at the Royal Marines Depot at Deal of ninety-six rooms for other ranks and twelve single rooms for senior non-commissioned officers. In the same month a new two-storey chief petty officers' block was opened in H.M.S. "Collingwood" (R.N. Electrical School at Fareham) as the first step in a plan to rebuild the whole of the accommodation in the school. In the United States Navy the highest practicable standard of habitability is now accepted as a military characteristic, but the recently completed British carriers—"Ark Royal" and three ships of the "Hermes" class—show that the Admiralty have also very much in mind that a high standard of habitability is essential for the fighting efficiency of a ship. Many of the living compartments are fitted with air-conditioned ventilation; large dining halls are supplied from galleys containing the most up-to-date machinery and electric cooking equipment. Canvas bunks are fitted for all ratings and mess decks are furnished with settees, and tubular steel tables and chairs and modern laundry facilities are provided with electrically driven equipment as in use ashore.

### Personnel

Both 1955 and 1956 will long be remembered for the sweeping reforms made in the officer structure of the Royal Navy. In 1955 executive officers, on promotion to Commander's rank, were divided into two lists—a "Post List" for officers eligible for seagoing commands, and a "General List" for those eligible only for command of shore establishments and for staff and administration duties. At the same time, the use of the suffixes (E), (L) and (S) and the wearing of distinctive lace by non-executive officers (other than medical) were discontinued. Marks of respect were also made the same for all officers. These revolutionary changes—which, incidentally, went a long way towards solving the difficult and long-standing problem of the status and prospects of engineer officers—were followed in May of that year by the first cadet entry into Dartmouth under the new eighteen-year age scheme of common entry. The new scheme was accompanied by the award of scholarships to enable suitable lads aged sixteen to remain at school and in the light of the difficulty hitherto in obtaining suitable applicants for Dartmouth, it is interesting to note that the first year of the scholarship scheme produced 840 candidates for the ninety vacancies offered. Early last year the new officer structure was rounded off by further drastic changes. As from January 1, 1957, executive, engineering, supply and secretariat, and electrical officers are combined into a single General List. Apart from electrical specialists, whose training requirements differ, all these cadets from May, 1957, onwards will simply join as naval officers and not for any particular branch. After three terms at Dartmouth they will be allocated to a specialisation, depending on Service requirements, aptitude and individual preference. These General List officers will train together until the end of their first period in the Fleet. Up to the middle ranks they will

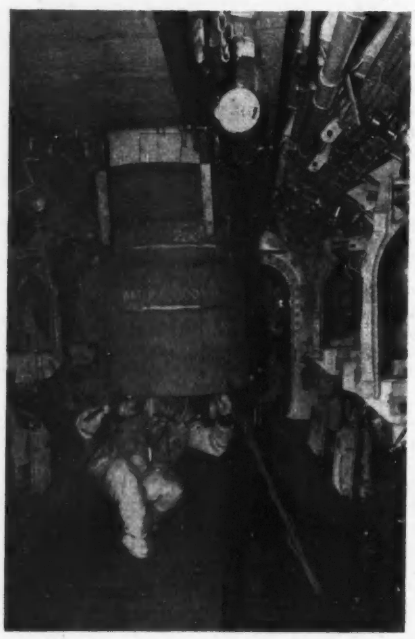


**Fig. 13—Submarine compartment with twill trunk let down from hatch. Water levels after flooding compartment at 100ft and 200ft are indicated on the trunk**

usually be employed in their own specialisations, though there will be some interchange of appointments. Eventually, promotions to the rank of Captain and above will be pooled. All will have equal powers of command, except that seagoing and aircraft commands are necessarily reserved for those officers with the appropriate experience. Above the rank of Lieutenant-Commander, only Post List officers will command seagoing ships. The entry of cadets is to be regulated with the aim of being able to promote three out of four Lieut.-Commanders to Commander and the minimum age of compulsory retirement for General List officers will eventually be raised to fifty. Branch List officers have been renamed Special Duties List officers, with the title henceforth of "Lieutenant," &c., instead of "Senior Commissioned Officer," &c. In view of the reduced cadet entry not only will more use be made of these first rate officers, but a Supplementary List of Officers is also to be introduced for limited duties, mainly for air crew. These latter officers will be engaged for twelve years, with the option of withdrawal after eight. Some will be selected for a pensionable career.

Soon after the rounding-off of the officer structure, revolutionary improvements were introduced in the pay pensions, allowances and conditions of service of naval personnel. A nine-year engagement replaces the existing seven (Special Service) and twelve-year engagements except for artificers whose extensive training requires their joining for twelve years over the age of eighteen. After nine years a rating may volunteer for a further five years, and subsequently for another eight years to complete time (twenty-two years) for pension. Artificer apprentices may re-engage to complete time for pension before completion of their first engagement. Opportunities for still further engagements are available for suitable men. Pay and pension scales for both officers and men have been very considerably increased. A Chief Electrical Artificer, for example, aged thirty-three, married, with fourteen years' service over the age of eighteen and three good conduct badges, now receives £17 10s., instead of £13 7s. 9d., weekly, plus about £3 a week in food, accommodation, cheap clothing, &c., provided by the Service. On retiring after twenty-two years' service he receives as a Chief Petty Officer a pension of £2 17s. 10d. instead of £2 6s. 4d., plus a tax-free terminal grant of £275. Similarly, on promotion a Commander receives pay of £1441 instead of £1122 a year and on retiring in that rank a pension of £800, instead of £675 a year, with a tax-free terminal grant of £2400. Following the General Service Commission under which most ships commission for eighteen months only and are away from the United Kingdom for not more than one year, a centralised drafting scheme is to be introduced this year to replace the present Port Division system. The new organisation will ensure that ratings will have equal promotion prospects within their categories and fairer shares of duty afloat and ashore. The rating of boy has now disappeared after more than three centuries and lads of fifteen years of age can join the Navy not only in the seaman branch, but also in the engineering and electrical branches and the Fleet Air Arm. They join as Junior Seaman, Second Class, Junior Engineering Mechanic Second Class, &c. Junior ratings entering above the age of sixteen and a quarter years go directly to the appropriate new entry establishment, as hitherto.

Vote A provides for a maximum strength of 128,000 as at April 1, 1956, the number being gradually reduced to 120,000 by the end of this financial year. Regular recruiting continues to decline though much less sharply than in the previous two or three years. There has, in fact, been an increased number of recruits for the engineering mechanic branch. About 40 per cent of naval ratings now re-engage to complete time for pension, but the proportion of Special Service (seven years' active service) who re-engage still remains very low. Some 8000 of these men are due to complete their engagements this year. None the less, it is anticipated that the number both of regular recruits and of re-engagements will increase as a result of the improved pay and conditions of service and it should be possible in the current year to reduce the entry of National Service men from 6000 to 2000. The Reserve situation may be regarded as very satisfactory. The Royal Fleet (fully trained) Reserve has been swelled by the large numbers of seven-year men completing their active service time and now numbers about 31,000. The Royal Naval Reserve (Merchant Navy) has risen to a total of 5200

officers and men and there are some 4000 officers and 9000 ratings in the Royal Naval Volunteer Reserve. National Service men do their part time service in the new Royal Naval Special Reserve, which has a strength at the present time of 17,600. Finally, the Royal Marine Volunteer Reserve remains at a strength of approximately 1700 officers and other ranks.

### Operations and Exercises

The value of aircraft carriers in a limited war was clearly shown in the recent operations in Egypt, when British and French carrier-borne aircraft delivered a succession of strikes on military objectives and naval targets amounting to a total of 2000 sorties. Over 100 ships of different types were involved in our naval operations. These included the bringing forward of the seaborne assault and follow-up forces ; the maintenance of naval cover for carrier and other seaborne forces ; the positioning of watching patrols and air warning pickets ; and the provision of anti-submarine escorts for all groups at sea. As in past years, ships and aircraft of the Royal Navy have continued throughout 1956 to exercise with the forces of other N.A.T.O. Powers. All these exercises have the same object in view—to ensure effective co-operation in the vital task of defending the sea communications. For the first time armed forces from Portugal co-operated in April with the forces of six other N.A.T.O. Powers in a large-scale convoy protection exercise in the Mediterranean. Other important exercises were a joint sea and air force operation in the Far East, in which ships of the Royal Australian and New Zealand Navies, the British carriers " Albion " and " Centaur " and the French carrier " Lafayette " took part ; and a large-scale minesweeping exercise in the North Sea carried out almost entirely by 700 officers and men of the R.N.V.R. in coastal minesweepers.

# Aeronautics in 1956

No. II—(*Concluded from page* 19, *January* 4)

THE outstanding feature of civil aviation recently has been the endorsement by the operators of the high-performance jet airliner. These aircraft are in every way ambitious, all of them being larger than any civil aircraft in existence, except the Saunders-Roe " Princess " flying boats, and considerably faster than the very heavy bombers that have been the " big stick " of the U.S.A.F. Strategic Air Command. They are all larger—some twice as large—as the " V "-bombers and the U.S.A.F. standard medium bomber, the " Stratojet," and are undoubtedly derived from the studies made in building the latest strategic bombers, mighty jets of 160–180 tons, attaining 630 m.p.h.

In the case of the first of these machines to appear, the Boeing 707 (Fig. 12), the connection is particularly close, since it was projected both as a transport and as a refuelling tanker able to operate at the altitudes adopted by jet bombers on operations : the KC-97 " Stratofreighter " compelled the bombers to waste fuel in a descent to its own altitude, and its lack of speed was a tactical handicap. The KC-135 " Stratotanker " will carry about 100 tons of fuel and, having Pratt and Whitney J.57 engines in common with the " Stratofortress," can make any desired division between fuel transferred and consumed. Four hundred of these aircraft, which have a span of 130ft 10in, have been ordered, and the first was completed last year. The " Jet Stratoliner " (it will be recalled that the " Stratoliner," first pressurised airliner, had four piston engines) has three major variants, the first of which, the 707-120, is comparable with the KC-135, having JT-3 engines which are the civil equivalent of J.57's. The 707-220 has JT-4 engines, civil versions of the more powerful J-75; the 707-320 similar engines in a larger airframe of 141ft 6in span. Other large engines that can be specified are the Rolls-Royce " Conway " and the Bristol " Olympus."

This aircraft is typical of the American jet airliners, all of which are low-wing monoplanes of about 35 deg. sweep with single-deck hulls (defined in section by two arcs of circles) into which the wheels retract, propelled by four engines in separate pods. The 707 is essentially conventional in construction, but the ailerons at the wing tips are locked once the flaps are up, control passing to small ailerons behind the inboard engines, thus avoiding aileron reversal at high speeds due to torsion of the wing. The inboard ailerons are augmented by spoilers which, when port and starboard sets open together, act as air brakes. The ailerons and tail surfaces are operated manually through control tabs : trimming is by an adjustable tail plane. Reports indicate that the handling qualities have surprised the pilots of propeller-driven machines, the big airliner being able to orbit and approach at conventional speeds, and make major corrections close to the ground.

Although silencing will be mandatory, at New York at least, the system of noise reduction and thrust reversing to be used by Boeing is not yet known, although various corrugated nozzles and target or cascade brakes have been discussed.

These machines will carry between 98 and 125 passengers or, in the larger versions, up to 147 : the " Intercontinental " will gross 295,000 lb—132 tons—at take-off.

The Douglas D.C.8 also is available either with JT-3 or JT-4 engines, with basically similar airframes in each case : Rolls-Royce " Conway " engines have been specified for some of the " Intercontinental " models. The machine is slightly smaller, grossing 287,500 lb and being 139ft 8½in in span, and can carry up to 131 passengers. A particularly interesting feature of the design is that the critical Mach number of the wing root is raised by the use of negative camber. This technique, which was, we believe, first proposed by W. F. Hilton at the National Physical Laboratory, gives a minimum super-velocity for a given lift coefficient.

The control aerodynamics are also different from those of the 707, the inner and outer ailerons being adjacent outboard of the flaps, the outer being driven from the inner by a spring and, therefore, becoming less effective at high speeds. Spoilers are fitted in front of the flaps, but are used only to destroy lift once the aircraft has touched down, and thereby allow heavier braking : air brakes are under the centre section.

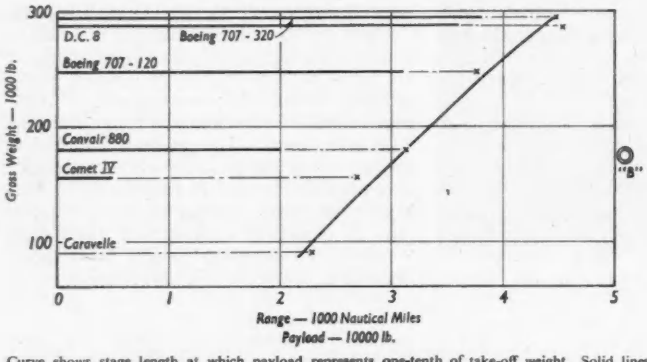
Both these " Intercontinental " aircraft are capable of flying a 4000 nautical mile stage with a capacity payload. For shorter range work there are similar but smaller machines, the lighter versions of the " 707," the D.C.9, and the Convair " 880." The " 880 " is to be equipped with the remarkable General Electric J.79 engines, which power the highest performance military aircraft, in a civilian form, and has the noteworthy cruising speed of 660 m.p.h. if flying at low altitudes on short stages. In appearance it is distinguished by a tail plane mounted on the fin.

These immense aircraft have raised correspondingly major problems. Even such a large manufacturer as the Douglas Aircraft Company is raising fresh capital in order to build the machines, and many of the operators are faced with re-equipment costs of extraordinary magnitude ; contracts for " Intercontinental " machines vary around £2,000,000 each. The facilities required to operate them are similarly on a vast scale ; take-off distances for the fully laden case are at or near 9000ft, though where the rejected take-off provision defines the distance, a " stop-way " allows a saving in concrete. Because of the great cost and relatively short

**Fig. 12—Precursor of the high-subsonic airliners of the immediate future, the Boeing " 707 " prototype is seen taking off from its makers' field. Visible are the large flaps, disposed to avoid the jet exhausts, the narrow-track undercarriage, retracting into the fuselage, and the " flying boom " refuelling equipment**

flight times of the machines, delays either before or after landing are intolerable, and the demand has already been made for air traffic control and passenger handling facilities of greatly increased capacity. The vast fuel tankages—63 tons on the D.C.8—will render mobile refuellers futile and require hydrant installations under the apron. Projects have been suggested to taxi the machines by means of ground power units in order to save fuel and avoid jet noise and blast. The problem of sweeping clear all tarmacs and runways of small debris is bringing to light "vacuum cleaners" of hundreds of horsepower. The great capital cost of plant to overhaul turbine engines may force operators to relinquish their independent maintenance organisations. In the face of all these difficulties, more than 225 of the big machines and 40 Convair 880's have been ordered—quantities which should realistically amortise the makers' overheads and appear to come close to meeting the whole of the anticipated demand for air transport.

There are, of course, excellent reasons for this choice; in essence, that only a large aircraft can fly long stages economically, and only a fast aircraft can carry enough passengers to pay for itself. The need for long stages is easily distinguished; apart from the attraction to travellers of flying, say, direct from Paris to New York, each refuelling stop costs time and money, introduces an extra risk of diversion or abandonment of a flight due to bad weather, and involves additional administrative, traffic control and meteorological staff. Given the necessity of long flights, the relationship between range and aircraft size must be responsible for the adoption of these extra-




Curve shows stage length at which payload represents one-tenth of take-off weight. Solid lines show payload for a stage length of 3000 n.m.

**Fig. 13—Influence of size on performance of jet airliners**

ordinarily heavy machines. For a given aircraft, range and payload are, of course, interchangeable within limits, the maximum—zero payload—range being of little interest, and the range with capacity payload being subject to wide variation at the designer's desire. In Fig. 13, therefore, we plot the stage length attainable at a payload of 10 per cent of the take-off weight, which, for basically similar aircraft, should imply similar overhead costs per ton or passenger; the curve shows clearly the advantage of the larger machines.

It is perhaps necessary to examine the validity of this plot.* In determining stage distances as distinct from still air ranges, a host of assumptions regarding operating procedures, fuel consumption in taxi-ing, and other conjectural matters must be made. It is therefore not to be assumed that the figures of one manufacturer correspond in every detail with those of another. It is also the case that such fundamental variables as the engine performance or weight are still being established while the aircraft are being built, and thus the calendar time at which data are prepared is not without influence. These considerations are even stronger when operating costs are considered—for example the constitution of flight crews is not yet determined—and for that reason this more direct comparison is unattractive. Since, however, a curve passes close to the points, it is considered that this plot of "10 per cent payload" range is not sensitive to the lesser variables in performance prediction.

The number of points is, of course, undesirably small, but jet airliners are costly to design and even more costly to develop, quickly, to operational status. (Manufacture of the Boeing jet transport prototype began in 1952—delivery to operators will not be before late 1958.) Due to the lack of complete data, it was not possible to include the T.U.104 (seen in Fig. 14), the only jet at present in service with the airliners. It is, of course, necessary to restrict the plot to machines which are fundamentally similar; the point for a long-range Bristol "Britannia" is off the chart at *B*.

Further corroboration of the soundness of this treatment comes from an examination of the points; since the "707-320" and "707-120" will naturally include many common components, it would be expected that the heavier machine would appear more favourably. Similarly, since the "Comet" is by far the oldest design of jet airliner extant, and the Mark IV is radically modified from the original concept, it is perhaps surprising that it lies so close to the curve. (The "Comet" has the advantage, of course, of being nearer to actual service; it may reach the air lines as much as six months before the Boeing 707-120.)

It being established that for longer ranges larger aircraft must be used, it follows as a corollary that over a given stage length the larger machines are more efficient. To confirm this, there have also been included on Fig. 13 the payloads that can be carried over a 3000 nautical mile stage, in the form of the heavy lines against each aircraft. For the "Caravelle," the smallest of the jet airliners, the payload at this distance would be zero; for the three heaviest machines the figure is the capacity payload. Thus the conclusion is inescapable that no less ambitious machine will be able to compete against the giants, where the traffic and terminal facilities to sustain them exist. The "880," it will be recalled, has the advantage of even greater speed, and, particularly important over shorter stages, short time to height; twelve minutes to 33,000ft is quoted.

**Fig. 14—"Aeroflot" is the only airline with jet airliners in service; here one of their "TU-104" machines is seen at London Airport. It grosses about 60 tons and cruises at up to 560 m.p.h.**

Some consideration should be given to aircraft of different character; a very great improvement on the performances discussed could be realised by a laminar flow aircraft, and this, rather than the supersonic transport, may be the next major transition in this country. Handley Page is particularly interested in the potentialities of boundary layer control, but there does not at this date appear to be confidence that a laminar layer can be reliably maintained. It will be recalled that our analysis showed the turbo-prop to enjoy an immense advantage: however, the cruising speed of propeller-driven machines is expected to be 200 m.p.h. less than that of the jets, and long flight times are not only unattractive to the passenger, but expensive in attention and refreshments or the space and weight of sleeping berths. Reducing the problem to its barest essentials, a "Britannia" with its slightly lower payload and much lower speed, would accumulate perhaps half as many ton-miles per annum as the largest jets; correspondingly, its cost is of the order of £1,000,000. But the airlines, probably foreseeing that in years to come the upward trend of speed, however gradual, will displace the propeller completely, have mostly chosen to make only one change in power plant, from piston to turbo-jet. Their confidence is eloquent testimony to the ability of the aeronautical engineer to meet the challenges facing him.

The observer in Great Britain, of course, cannot study this situation without regretting the cancellation of the Vickers "V.1000" transport by the Ministry of Supply in 1955; as a result B.O.A.C. are to be equipped with Boeing 707 aircraft instead of the Vickers V.C.7, which, with four Rolls-Royce "Conway" engines, would have been of comparable performance. Figures provided by the manufacturer show that a point for this aircraft, grossing 268,000 lb would have laid off the curve of Fig. 13 to the same extent as the 707-120.

* The data to compile Fig. 13 were taken from *Flight*, July 6, 1956

# Electrical Engineering in 1956

No. II—(*Concluded from page 12, January 4*)

### Transonic Wind Tunnel Drive

THE Aircraft Research Association's transonic wind tunnel at Bedford, which was opened by H.R.H. the Duke of Edinburgh last May, incorporates an interesting electrical drive. This tunnel, which was described in THE ENGINEER, May 11, 1956, and is illustrated on Plate 6 of the current issue, has a working section 9ft wide by 8ft by 8ft high and is designed for the testing of models of 3ft to 5ft span at speeds up to Mach 1·3. The tunnel is of orthodox design and makes use of a closed circuit with a contraction ratio of 11 to 1 and diffusers of about 5½ deg. cone angle. Air flow in this circuit is produced by a two-stage fan with twenty 21ft diameter blades to each stage. Static adjustment of the blade angles is possible over a small range to provide means of varying the fan power to suit the speed of the driving motor. Flaps which are fitted on the pre-rotation vanes can be adjusted while the tunnel is operating to enable the input power and the air speed to be varied within narrow limits without any change in the rotational speed of the fan.

The fan is driven by a 25,000 h.p., 12-pole, slipring induction motor coupled to a 1500 h.p. d.c. motor with Ward-Leonard control. Coarse control of air speed in the tunnel is effected by adjustment of a liquid resistance in the rotor circuit of the slipring motor and fine adjustment is obtained by Ward-Leonard control of the d.c. motor. With composite drives of this kind it is possible to hold the fan speed to 0·1 per cent. The d.c. motor is designed to develop a large torque at low speeds and is therefore used to start the fan, after which the a.c. motor is switched on when the speed has reached about 200 r.p.m. This procedure reduces the starting current surge.

In the accompanying illustration we show the main drives of the tunnel. The motors, control gear, 11kV switchgear, l.t. auxiliary switchgear, main incoming 33/11kV transformer, l.t. transformers and auxiliary motors for this wind tunnel installation were supplied by the English Electric Company, Ltd.

The 8ft by 6ft transonic wind tunnel at the Royal Aircraft Establishment, Farnborough, also went into operation during 1956. It is a modification of a tunnel which went into commission in 1942 and was known as the high-speed wind tunnel. The original main fan drive, as supplied by the British Thomson-Houston Company, Ltd., consisted of a 4000 h.p. tandem d.c. motor and Ward-Leonard motor generator set. The modifications to make the tunnel suitable for transonic work involved the coupling of a B.T.H. 8000 h.p., six-pole, 6600V slipring induction motor to the fan shaft. Coarse speed control is obtained by a liquid regulator in the rotor circuit. Load sharing between the a.c. and d.c. motors is governed by an electronic regulator. Another electronic regulator acts on the fields of the two cascaded generators and keeps the speed to within 0·1 per cent of the top speed.

### Mine Winder Drives

A new form of automatic control for winders driven by induction motors was demonstrated in June on one of the B.T.H. 1200 h.p. sinking winders at Lea Hall Colliery in Staffordshire.

This control consists of a regulating system using an amplidyne and servo-motor in such a way that the induction motor speed is made to correspond to a value set by a potentiometer—a process which has been possible hitherto only with Ward-Leonard systems. The speed is maintained independently of the load, whether the load is being raised or lowered. It is important for automatic winding because it enables the winder speed to be accurately reduced by means of cam gear at the end of the wind. The demonstration covered the raising and lowering of full load, medium load, and light load, each for a range of speeds consisting of full speed, half speed, and creep speed. In each case the speed was shown to stay at the set value once it had been reached. The cam gear was shown in action, and it was demonstrated that the speed could always be reduced by it to a set creep speed just before the final stopping position, so that that position could be attained with accuracy.

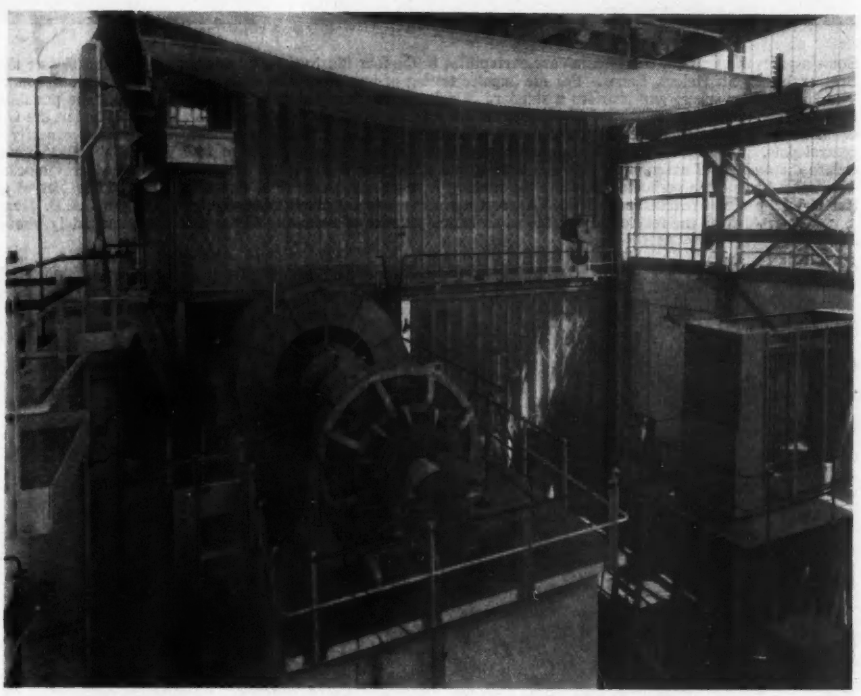
A fully automatic G.E.C. skip winder of 3000 h.p. was commissioned at Cwm colliery in 1956. The control gear incorporates a creep speed regulator and brake impulse timer to provide the required degree of accuracy in decking. The creep speed regulator automatically introduces a correction dependent upon the load and operating throughout the deceleration period. The brake impulse timer is a further refinement which takes account of the actual speed immediately before decking and advances or retards slightly the instant of braking as may be necessary. It is, essentially, a motor-operated rotary time switch set in motion by an impulse from a shaft switch and reversed by a second impulse from another switch installed at a second check point a few feet from the first. The angle traversed by the moving contact arm between the two impulses—that is, between the instants when the cage passes the check points—determines the time delay of the brake application, since the signal to the brake solenoid is given when the contact arm encounters an adjustable contact on its return travel. The adjustment of this contact allows for the inherent slight time lag of the brakes.

### A.C. Railway Electrification

An important decision about the £1200 million modernisation plan for British Railways was taken last March when it was announced that the standard system for future electrification would be 25kV at 50 c/s. This system will be used for 1210 of the 1460 route miles to be electrified on British Railways. A total of 820 route miles will be on the main trunk lines : Euston, Manchester, Liverpool ; King's Cross, Doncaster, Manchester, Leeds and, possibly, York ; and Liverpool Street, Ipswich, in extension of the existing electrification, which will be converted from 1500V d.c. to 6·6kV a.c. at 50 c/s.

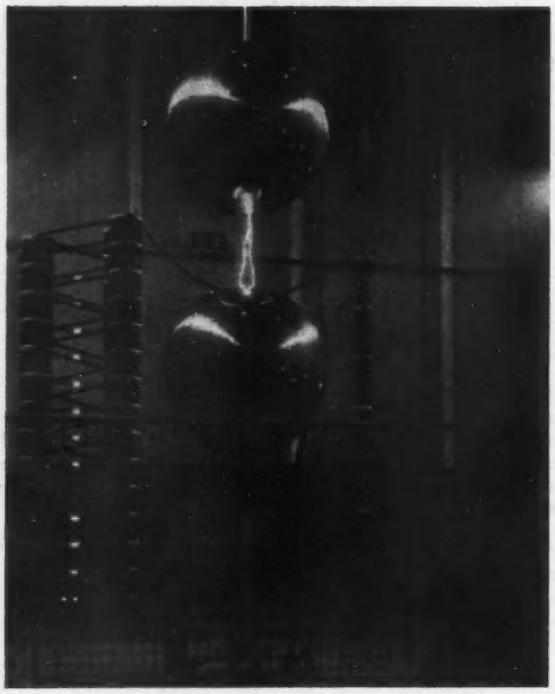
The economies to be derived from the high-voltage, single-phase, a.c. system are exemplified by the results of a comparative survey of the London Midland Region's main route from Euston to Manchester and Liverpool. This survey showed that the capital costs would be £117·8 million for 25kV, a.c., compared with £123 million for 1500V d.c. Even greater capital savings could be expected on other lines where the contingent costs of providing electrical clearances, and the fraction of the total cost attributable to locomotives, should both be less than on the Euston, Manchester, Liverpool route. On this route a reduction of £1,000,000 in annual costs is expected to accrue from the adoption of a.c. instead of d.c., and corresponding economies can be anticipated on other lines.

The main reasons for the saving in capital

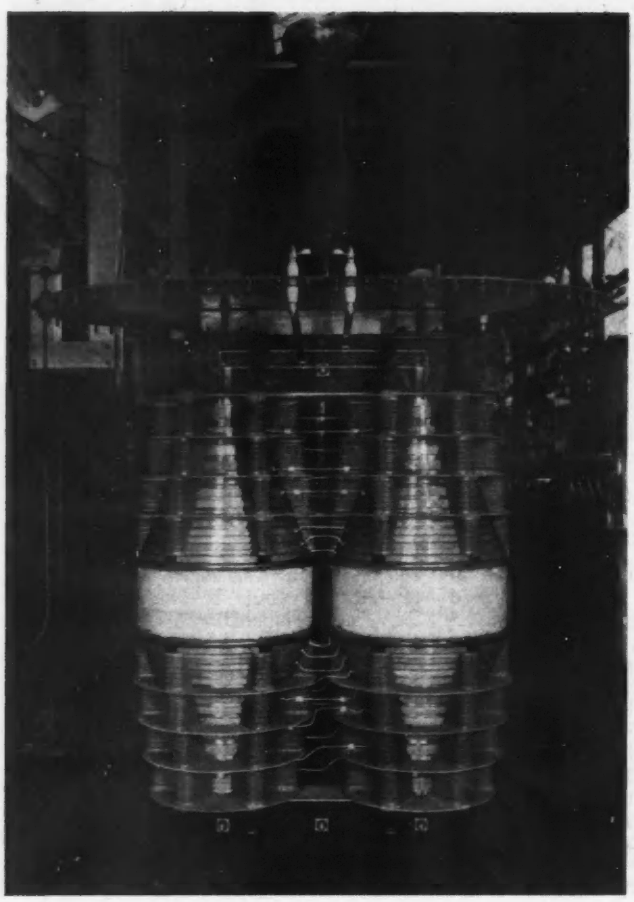


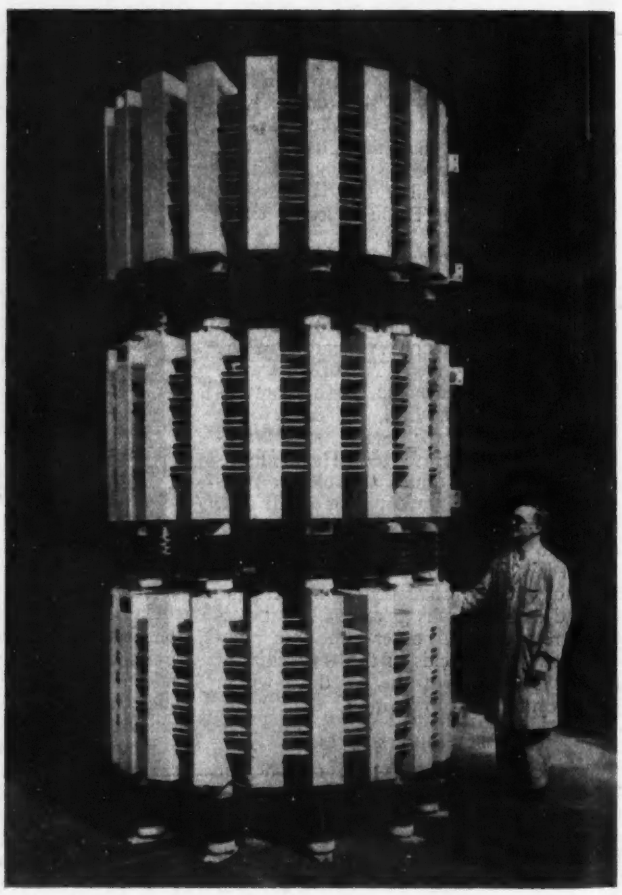
**The fan drive for the Aircraft Research Association's transonic wind tunnel at Bedford consists of a 25,000 h.p., twelve-pole slipring motor direct-coupled to a 1500 h.p. d.c. motor, both supplied by the English Electric Company, Ltd.**

# ELECTRICAL TRANSMISSION



Some aspects of electrical transmission are exemplified in the four illustrations on this page. The first picture shows part of the new high-voltage laboratory of Pilkington Brothers, Ltd., St. Helens, Lancs. For the impulse testing of insulators it is equipped with a fourteen-stage impulse generator, to give a peak impulse voltage of 2300kV. The 2m-diameter sphere gap provides a standard of voltage measurement according to B.S. 358. The possibilities of uprating conventional switchgear by refinements in design are typified in our second illustration, which shows a 5000MVA oil circuit breaker under test at the G.E.C. high-power testing laboratory at Witton. The main components of this circuit breaker are common with those of the 3500MVA equipment, the increased capacity having been obtained by designing new contacts and arc control pots. Our third illustration shows the wound case of a test transformer of 150kVA, 900V/250kV, made by Foster Transformers, Ltd., South Wimbledon. To reduce the amount of external support and bracing the manufacturer made use of specially designed cast blocks of silica-filled Bakelite polyester resin. These blocks were spaced round the perimeter to locate the winding formers and ensure rigid clamping. The fourth picture shows one of nine B.T.H. cast-in-concrete reactor tiers (for 6kV, 5 per cent reactance on 2·6MVA), recently shipped to Intechmij, N.V., Holland, for the G.E.B. Haarlem. The incoming and outgoing connections are supported from the reactor to suit the usual Dutch practice of mounting feeder reactors immediately above or below the associated banks of switchgear





outlay, as indicated by the comparative survey, were that a.c. electrification would require only twelve transformer substations, which would be owned by the Central Electricity Authority and that, because of the proximity of existing C.E.A. supply points, only 17 miles of new feeders would be needed: d.c. electrification, on the other hand, would require seventy rectifier substations and 250 miles of 33kV cable. Without ignoring the possibilities of developments in the application of the a.c. series motor, British Railways propose to concentrate initially on the rectifier locomotive with d.c. series motors, and it was this locomotive that was compared with the straight d.c. locomotive in the survey. Because of the superior adhesion, weight-for-weight, of the a.c. locomotive with d.c. motors, lighter locomotives could be used for a given duty and the reduced wear and tear on the track would react favourably on the overall cost of the modernisation plan.

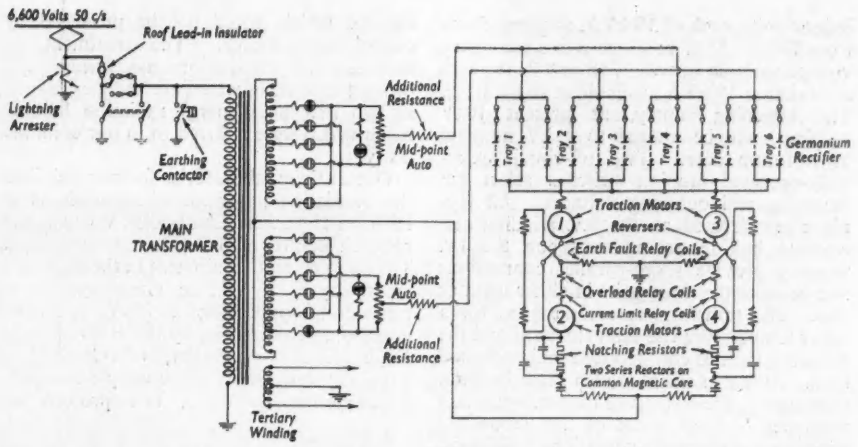
The Manchester–Crewe section will be the first stage of the electrification and will serve as a proving ground for new equipment.

The choice of the single-phase a.c. system of electrification at 50 c/s, and the present preference for the rectifier locomotive with d.c. motors, gives added interest to a 750kW, 1500V germanium rectifier built by the British Thomson-Houston Company, Ltd., for trial service on a rail motor coach on the Lancaster–Morecambe–Heysham line. Early last year, after completing its initial trials on that line, the train was transferred to the Eastern Region for trials between Fenchurch Street and Bow Road, which, it will be recalled, is at present electrified at 1500V d.c., and is later to be converted to 6·6kV a.c. Accordingly, the trials were made between midnight and 3 a.m. when the a.c. supply at 6·6kV could be substituted for the normal d.c. The germanium rectifier installation, which was illustrated and described briefly in our issue of January 13, 1956, is a forced-air-cooled equipment of 750kW capacity. It consists of six racks of hermetically-sealed 1kW germanium rectifier cells bridge-connected (as shown in the accompanying diagram) for full-wave rectification.

Last August, the Eastern Region announced that it proposed to modify the electric locomotives operating on the Manchester–Sheffield–Wath line. Rheostatic braking is to be incorporated in the fifty-eight $B_0$–$B_0$ locomotives, to be complementary to the existing regenerative braking system. With this modification, when it is required to stop a train or reduce its speed below about 16 m.p.h., at which point the regenerative braking system becomes ineffective, it will be possible to change the connections, disconnecting the motors from the overhead contact wire and connecting them to the starting resistances.

### Germanium Rectifiers in Industry

A number of B.T.H. germanium rectifiers went into industrial service during the year: they included a 1000kW, 225V set (the first commercial installation of its kind) for Imperial Chemical Industries, Ltd.; a 30,000A, 20–50V set for Société Pechiney; two 15,000A, 18V sets for the Steel Company of Wales, Ltd.; and two 7500A, 18V sets (one of which is illustrated here) for Richard Thomas and Baldwins, Ltd. The set illustrated embodies closed circuit cooling, with an air-to-water heat exchanger. As a result of development work on germanium rectifiers an improved design of germanium cell of reduced size was developed and went into service in 1956.

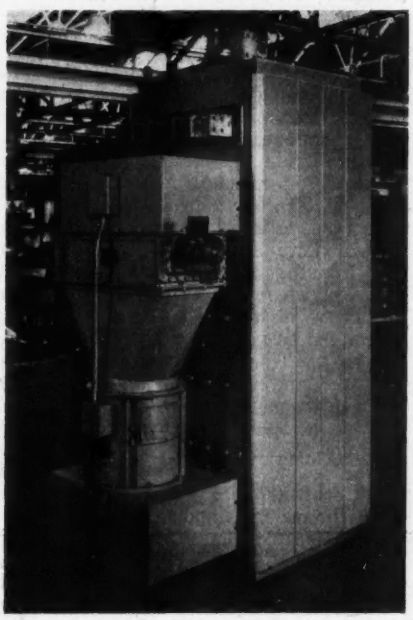



**Simplified circuit diagram of germanium rectifier experimental installation for single phase, 50 c/s locomotive**

### Electric Glass-Melting Furnaces

Progress in the melting of glass by electrical heat was announced on May 30 last year, when Mr. A. Gell, of the British Heat Resisting Glass Company, Ltd., presented a paper to the Society of Glass Technology. This paper contained some general observations on the design and operation of an all-electric furnace for melting glass. The main advantage claimed for this furnace is its high thermal efficiency. Because the heat is applied directly to the glass, heat losses of 40 to 50 per cent or less are claimed compared with conventional furnaces in which heat losses up to 90 per cent are common.

Little technical information is available about the furnace, which has been under development by the British Heat Resisting Glass Company, Ltd., for the past five years. Briefly, the furnace consists of a six-sided melting chamber in which heat is generated by passing current through the glass charge between electrodes on two of the facing walls. The dimensions of the furnace are determined by the composition of the glass and by the electrode voltage, which, in commercial furnaces, cannot exceed about 600V without creating complications in the design of the electrical equipment. The electrode linings of such a furnace may be of molybdenum strips to which current is transmitted by water-cooled feeders passing through the refractory insulation. Power at the appropriate voltage is derived from three-phase transformers; regulation is either by stepless voltage regulators or by saturable reactors, the former being preferred because they provide a less peaky current waveform.



**7500A, 18V germanium power rectifier made by the British Thomson-Houston Company, Ltd. It has closed circuit cooling and air to water heat exchanger**

The power required for a given rate of melt of a specific glass is critical and any error in the initial settings is likely to give rise to unstable furnace conditions. But according to Mr. Gell's paper, once the correct settings have been made operation is stable "within limits of up to 5 per cent on either side of the conditions set for any rate of throughput, tending to hunt towards the set conditions, rather than away from them."

Automatic regulation of the furnace is possible. According to Mr. Gell, regulation of current and of the timing of the batch charger has been achieved by an electronic computer, which was controlled from a forehearth level control, consisting of a particle of radioactive strontium and a counter.

An electric boost melting system recently went into operation on one of the regenerative furnaces at the Charlton works of the United Glass Bottle Manufacturing Company, Ltd. This installation, which makes use of the Penberthey Boost Melting three-phase system, is stated to have increased the capacity of the furnace by 30 tons of glass per day without increasing its size, and to have improved the quality of the glass.

Electric power derived from three single-phase transformers is fed into the furnace via water-cooled molybdenum electrodes, each operating at a maximum current rating of 2000A per electrode. The current applied is in accordance with the load conditions of the furnace, which range from 100kW to a maximum load of 630kW, and the furnace is rated at about 5 tons of glass per 100kW.

The electrodes pass through the refractory side walls of the furnace, and heat is liberated in the glass itself, tending to give good glass melting conditions. In the area of molten glass adjacent to the electrodes convection currents are created, which energise the glass and assist in the "fining" process. After electric-boost melting the molten glass travels through a throat to the working end of the furnace where it is distributed by channels to bottle-making machines of the suction and flow type and, after annealing, the bottles proceed to the sorting department, after which they are either processed to meet customers' requirements or sold direct.

The furnace transformers are single-phase,

indoor units, each of 250kVA, stepping down from 9900/11,550V in six steps to a secondary voltage variable between 75V and 346V, with a maximum 250kVA available at any voltage. The incoming supply, at present 10kV nominal, will be altered to 11kV nominal at a future date. Two off-circuit externally-operated tapping switches select the incoming and outgoing voltages. All tappings are situated on the h.v. winding and external linking arrangements on the l.v. winding provide series-parallel connections and connect the three units in either delta or star. The transformers are designed for a lower temperature rise than standard and the cores are built of cold-reduced grain-oriented steel. An earth shield is also fitted between windings, as the method of furnace operation precludes a direct earth on the secondary windings under certain conditions. Although the three-phase, low-voltage winding is not earthed, an earthing electrode is inserted at the working end of the furnace, which reduces to a minimum the potential of glass at the bottle-making machine pick-up point ; the electrode is connected to large cast iron plates in the ground, which are in turn bonded to the bottle-making machines.

Operation of electric boost melting on this furnace is stated to be simple and flexible, relying, as it does, on the use of simple tapped transformers which are adequate to obtain sufficient voltage range, allowing for variation of resistance with temperature. To ensure the safety of the operator, the oil circuit breaker of the switch unit controlling the h.v. supply to the transformers is arranged for remote operation from a low-voltage control cubicle installed near the furnace. The electrical equipment for this boost melting furnace was supplied by Crompton Parkinson, Ltd.

### Computer-Controlled Milling Machine

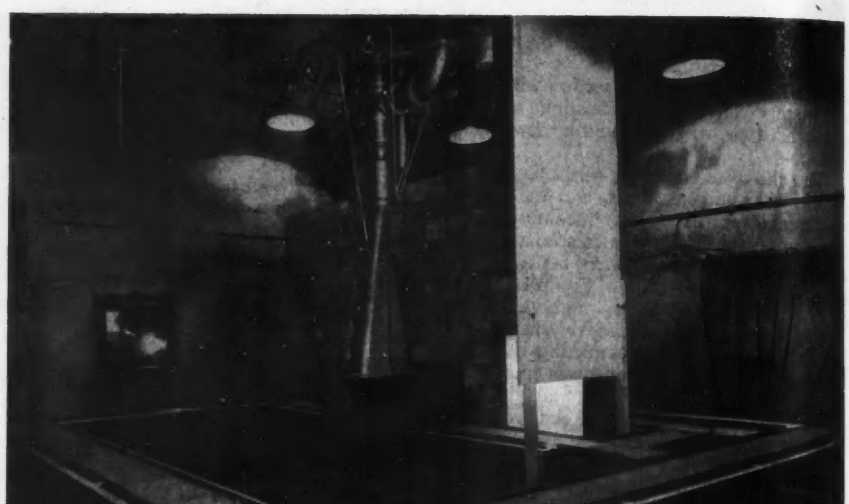
Some applications of electronics in industry are illustrated on Plate 7. Another interesting example, which is of considerable moment to all who are concerned with greater productivity in the machine room, is that of a milling machine adapted for computer control. This system of control, which was developed by Ferranti, Ltd., Edinburgh, was fully described in an article on page 326 of THE ENGINEER, April 13, 1956. Briefly, the basis of the system is that the movement of the milling work table along each of the three co-ordinate axes (which determines the profile to be cut) is equipped with an electro-optical method of measurement which has an inherent accuracy better than that of the machine itself. Positioning of the workpiece is effected continuously, throughout the milling operation, by a high-performance servo-mechanism using the electro-optical system as feed-back. The instructions given to each of the three servo-mechanism channels on the milling machine to produce the desired profile are formulated in a digital computer and recorded on magnetic tape (one per channel). These tapes are " read " in a control console and are there translated into electrical pulses to feed the servo-mechanisms that control the co-ordinate movements of the work table. We saw the system demonstrated last year, when an aircraft spar and half a waveguide of aluminium alloy were milled out of the solid. One digital computer can provide the required service for a large number of machines and their associated control consoles.

### Irradiation of Materials

High energy radiation, either from a reactor or from a particle accelerator, can promote, at ordinary temperatures, chemical changes which could not be produced by conventional means. The treatment of materials by irradiation has commercial prospects, some of which are being examined at two new high energy radiation laboratories which were referred to in our columns last year.

One of these laboratories for research into the irradiation treatment of materials, is at Hinxton Hall, near Cambridge, which is the research centre of Tube Investments, Ltd. The main piece of equipment in the radiation laboratory is a Van de Graaff generator capable of producing a 2MV beam of radiation. It was built by the High Voltage Engineering Corporation, of Cambridge, Massachusetts, and can be adapted to produce gamma radiation, fast protons or neutrons. When accelerating electrons with energies up to 2MeV, the normal beam current (maximum) is 250 microamperes. The generator is housed in a pressure vessel and operates in an atmosphere of 25 per cent nitrogen, 75 per cent carbon dioxide at 275 lb per square inch, which enables the overall dimensions to be kept small. Objects to be irradiated are taken on a series of conveyor belts from the control room into the radiation chamber, where the electron beam from the generator is scanned electromagnetically across the belt carrying the specimens. As can be seen from the accompanying illustration, the conveyor system traverses a labyrinth of demountable concrete walls, which provide the operators with protection against radiation effects.

The second installation is intended for work on the special properties of irradiated dielectric materials and takes the form of a 2MeV Van de Graaff particle accelerator at the Wood Lane laboratories of British Insulated Callender's Cables, Ltd. High-energy radiation produced by this equipment is being used to modify the structure and properties of conventional polythenes, for example. The physical and electrical properties of such materials are being studied with particular reference to their uses as cable dielectrics.



**Radiation room showing conveyor system whereby materials can be irradiated by a high-intensity beam produced by a 2 MeV Van de Graaff generator in the Tube Investments radiation laboratory at Hinxton Hall, Cambridge**

### Electrical Instrumentation

Progress in electrical instrumentation is well exemplified in the method devised for detecting leaks from punctured fuel cans in the Calder Hall reactors, as described in THE ENGINEER, October 19, 1956, page 538. In principle, the method is to " sniff " each of the fuel element channels in turn, taking, from each, small samples of the coolant gas, and to monitor these samples for radioactive components, using electrostatic precipitation and scintillation counting techniques. For the gas sampling process the 1696 fuel channels in each reactor are divided into eight separate areas, each controlled by a fifty-four-point gas sampling plant which registers back to a central control room. From each of the areas 212 gas sampling pipes are taken via steel plugs to manifolds outside the shielding which reduce the number of channels to fifty-three, by combining them in groups of four. The fifty-three pipelines are then connected to a selector valve and thence to a filter, a precipitation chamber and a scintillation counter. Samples of a gas are taken from each pipeline in turn and are filtered and passed to the precipitation chamber, where any radioactive gases are deposited by electrostatic precipitation on a wire. This wire is a motor-driven loop and during each sampling period of twenty-eight seconds a fresh length of wire enters the precipitation chamber, while the preceding length of wire, with its radioactive deposit, enters the scintillation counter and remains there for checking. This scintillation counter operates a rate meter which, in turn, gives an indication on a fifty-four-way recorder in the control room. If a high radioactive count is registered during any of the sampling periods a warning bell is sounded in the control room. A typical precipitator is illustrated opposite.

This system of detection was developed

by Plessey Nucleonics, Ltd., in collaboration with the U.K. Atomic Energy Authority. The recording instrument, which is installed in the reactor control room, is a modified form of Elliott self-balancing potentiometer recorder.

An example of remote indication by means of a closed loop television circuit is given in one of our illustrations. It shows part of a control panel at Castle Donington power station. On this panel there is a Marconi television receiver screen showing a televised picture of boiler water gauge levels.

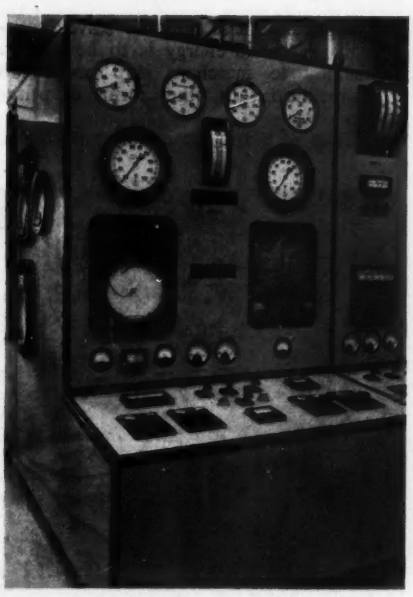
As recorded in THE ENGINEER, July 6, 1956, page 6, some interesting results have been achieved by using an electron microscope for direct observation of defects in crystal lattices. Working at the research laboratories of Tube Investments, Ltd., Hinxton Hall, Dr. Menter has prepared electron micrographs showing defects in the crystal lattices of metal compounds, at magnifications of 1,500,000 to 1. Thus visual confirmation has been obtained of the theory that the behaviour of solids under stress can be explained by the existence, in otherwise perfect crystal lattices, of defects, such as dislocations. Among the materials photographed by Dr. Menter are copper-and platinum-phthalo cyanine, and, using these materials, images of crystal planes separated by $10^{-7}$cm have been recorded, viewed edge on. One possible development of this work would be to study the movement of imperfections under stress by making cinematographic records. In this way, it should be possible to obtain a better understanding of the plastic, strength, fatigue, and creep properties of materials, in terms of the movement of imperfections of the kind discussed here.

### RADIO PROPAGATION BY TROPOSPHERIC SCATTER

Reference to British work on the possibilities of radio propagation by tropospheric scatter was made in THE ENGINEER, October 26, 1956, page 595. The principle of this system of propagation is that radio waves are directed into the upper atmosphere (troposphere), where scattering occurs, part of the energy being deflected forward and downward and reaching the earth again at a point remote from the transmitter. Scatter also takes place in the ionosphere, but only at frequencies below about 60 Mc/s, whereas tropospheric scatter, as a possible means of radio communication, promises to be useful at frequencies up to 10,000 Mc/s. Experimental equipment using the principles of tropospheric scatter has already yielded transmissions over distances many times greater than the " line of sight " limit which characterises ultra-high-frequency equipment now in general use.

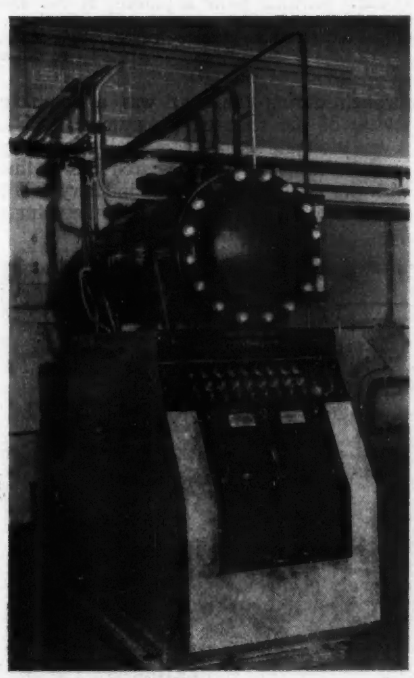
After propagation tests extending over several years, Marconi's Wireless Telegraph Company, Ltd., has now brought into operation a tropospheric scatter link between Great Bromley, Essex, and Sutton Bank, near Thirsk, Yorkshire, over a distance of about 200 miles. Field strengths are recorded continuously over this link. Preliminary tests have already been made over a 400-mile circuit to Aberdeen, and it is hoped later to establish a link over this distance.

The present transmitter, at Great Bromley, is housed in a trailer, illustrated here. Operating on a frequency of 858 Mc/s, the transmitter has an output of 500W and is capable of being frequency-modulated by a multi-channel signal or amplitude-modulated by a television waveform, or by pulses. The actual radiator consists of a 30ft diameter dish, the lower edge of which is mounted about 30ft above ground level ; this radiator is energised by a feed horn mounted on the transmitter trailer. The radio beam can be steered in the horizontal plane by positioning the transmitter trailer on an arc of railway track which is laid in front of the radiating dish. Adjustment of the beam in the vertical



**A Marconi closed-circuit television monitor on this control panel at Castle Donington power station gives a remote picture of boiler water level gauges**

plane is also possible, since the feed horn is mounted on a small boom, which can be raised or lowered. The receiver is contained in a mobile laboratory. To obtain the maximum mobility the receiving aerial,



**One of the precipitator units in the sampling system for detecting burst slugs in a Calder Hall reactor**

which is mounted on a trailer, is only 10ft in diameter.

Plans are in hand to set up high-power (10kW) transmitters and associated receivers at Newcastle upon Tyne, and in the London area, with the object of being able to operate up to thirty-six simultaneous telephone channels or a television link between these points, for tests and demonstration only.

Present results are such as to indicate a possible commercial future for communication systems making use of the tropospheric scatter principle. For the future, the ultimate limits of transmission will depend largely on the transmitter power available. With a power of 100kW it might be possible to achieve telegraph transmission out to distances of the order of 700 miles. The ultimate operational limits are not yet established, but there is a possibility of an eventual transatlantic television service by the tropospheric scatter system. It would, however, have to be carried out in a series of " hops," as the maximum range of reliable television transmission by any one link is only about 250 miles. A much nearer possibility is a direct European television link, for example, from Holland to Britain.

### TRANSATLANTIC TELEPHONE CABLE

The first transatlantic telephone cable link, providing thirty-five telephone circuits between the United Kingdom, Canada and the U.S.A., was opened during 1956. The main link consists of two one-way cables, each nearly 2000 nautical miles long and each containing fifty-two submerged repeaters laid at depths up to 2000 fathoms. As explained by Sir Gordon Radley in his presidential address to the Institution of Electrical Engineers last October, the whole concept of the transatlantic telephone cable depends on the submerged repeaters. Those installed in the deep sea section of cable are flexible one-way repeaters 2½in diameter and about 150ft long over the tails ; they were developed by the Bell Telephone Laboratories in America. In the single cable link between Newfoundland and Nova Scotia British repeaters are used, made by Standard Telephones and Cables, Ltd. They are equipped with directional filters to provide for two-way transmission along the single cable. The cable is of coaxial design, insulated with polythene of high molecular weight, and the bulk of the cable was made by Submarine Cables, Ltd.

In the presidential address referred to above, Sir Gordon Radley discussed the very promising future of repeatered submarine cables in world telecommunications. He examined present day limitations in repeater design and the prospects of progress. He foresaw a possible demand for the laying of a second cable across the North Atlantic at no distant date ; eighty circuits in a single cable or 200 in a twin cable system would be objectives only just outside the present limits of repeater spacing and cable diameter.

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ANTI-CORROSION COATING.—A protective coating material intended to safeguard structural steelwork subject to strong corrosive attack, particularly in industrial and marine localities, has been introduced by Jenolite, Ltd., under the designation, code CS 14. This material is stated to be entirely distinct from the firm's other products and is based on a rubber-modified epoxy resin. Briefly, properties claimed for the new coating are that it is impervious to moisture and has extreme resistance to acid and alkali attack. It remains unaffected by ketones and by mixed aliphatic hydrocarbons, and withstands constant splashing with these and other solvents for indefinite periods. The sealer " pre-cures " in twenty-four hours, we are informed, and may be over-painted with any kind of primer or coating after this period. Full coating strength and flexibility are achieved after seven days, and thereafter the sealer withstands temperatures of up to 150 deg. Cent. One of its more important characteristics, the firm states, is the degree to which it combines with the Jenolite RRN treatment.

# Shipbuilding and Marine Engineering in 1956

No. II—(*Continued from page* 25, *January* 4)

## Research and Development

ALTHOUGH the British Shipbuilding Research Association, under the leadership of Dr. S. L. Smith, has continued to pursue its programme of investigations, its activities in general research have tended to be overshadowed, if not obscured, by the interest taken in the development of atomic energy. The powering of the submarine "Nautilus" has been successfully accomplished and this, coupled with the announcements of American intention to develop a nuclear power unit for a merchant ship, and that the Russians plan to fit this form of propulsion in an ice breaker, has inevitably given rise to questions being formulated which ask whether appropriate efforts are being made in this direction in this country. With such questions being aired it is not without point to draw attention to the fact that the Association already has a team studying marine reactors at Harwell. This team was not the result of any sudden evolution of interest in atomic energy, but the next logical step following a close study of the problems involved in the application of this form of energy to merchant ships and years of contact with developments in this particular field.

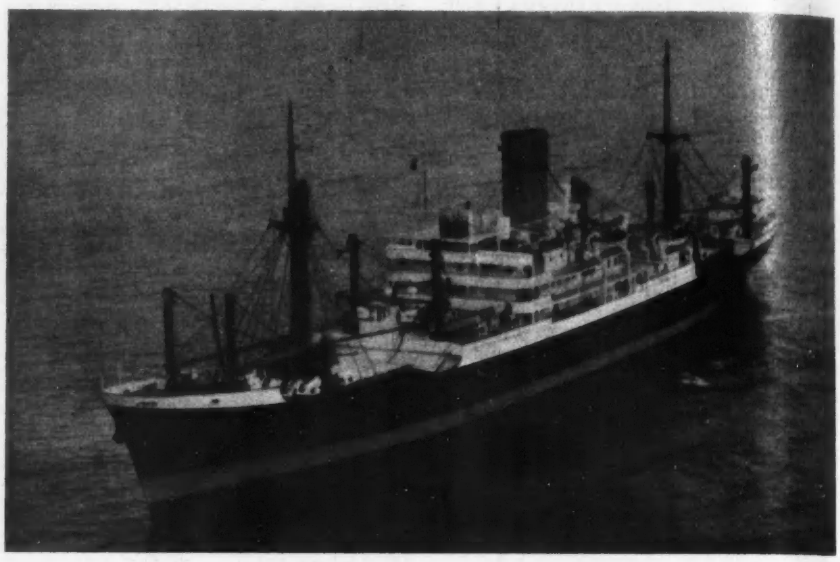
It is not always possible to advance on all technical fronts and, indeed, each country has its own particular problems and needs which, no doubt, have influenced the trend of development. In Britain the application of atomic energy to the production of electricity was given priority and we now lead in this field, while the United States concentrated on marine developments and, as a result, are further advanced in that field. The B.S.R.A. team at Harwell is in constant contact with research progress and is in a position to know when the time is opportune for marine applications to be developed. A feasibility study is being made by the team of the possibilities of such a development, because, for this particular application, both technical and economic problems have to be examined. These must be solved satisfactorily if atomic energy is to be applied successfully to merchant ship propulsion in competition with other forms of prime mover.

An item of particular importance carried through during the year was a complete review of the research programme. This, it was thought, was fundamentally necessary in order to ensure that research was in line with the requirements of the industry. The review did not necessarily reduce the volume of work, but did eliminate those items which were considered complete and amended the priorities accorded to other schemes to suit current progress. Research reports numbering twenty-four were prepared and issued to members, who also received six technical memoranda, while one paper was read before a technical society.

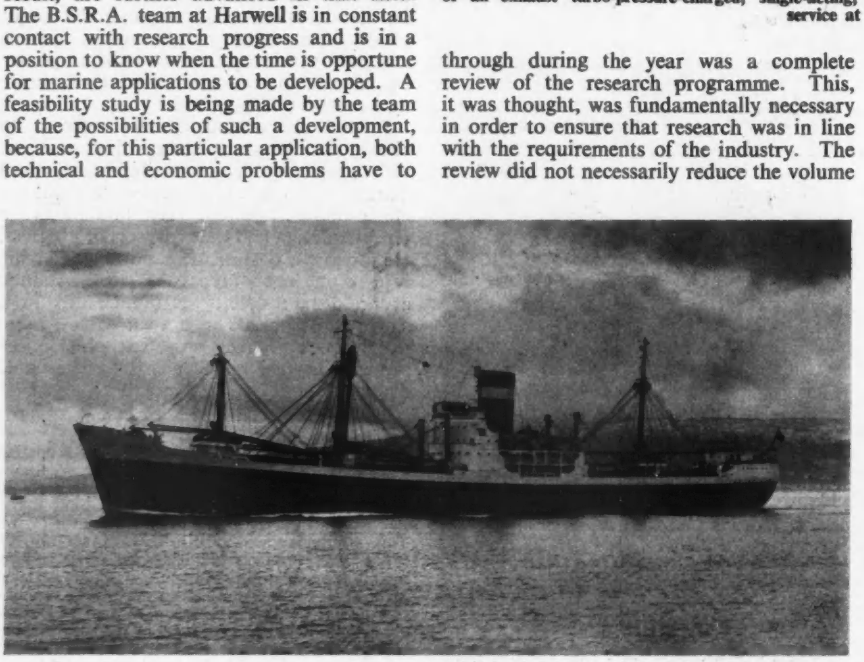
Further work was done on the methodical series, on the range of models and also on some additional models, the latter being used to provide data for filling in the gaps which had become evident in the original programme. The results were incorporated in two reports, one of which gave the data relating to models having a block coefficient of 0·875, while the other recorded the propulsion results using models of 0·70 block coefficient. Problems concerning coasters, tugs, trawlers, and other specialised craft continued to be investigated and a report was circulated giving the bollard pull of single-screw tugs. The effect of variation of the beam of trawlers received attention and the work advanced to a stage when a report could be issued.

Work on hull roughness was pursued, the hulls of several ships were inspected and a large number of surface roughness recordings were taken. A detailed examination of the results was put in hand. To increase the speed of taking records and to facilitate the work of analysis, suitable instrumentation was developed by the Association at its laboratory at Palmers Hill, Sunderland. The effect of shallow water upon speed and power continued to be the subject of study and in the field of propulsion the results of experiments on propeller blade sections, carried out by the aerodynamics division at the N.P.L., were reported to members. Further tests were arranged.

Research into structural problems was pursued and several reports issued upon the investigations carried out on box girders at the Imperial College of Science and Technology. One report was concerned with the effect of longitudinal stiffeners in transversely stiffened box girders, and another was a progress report on a frame box girder sub-

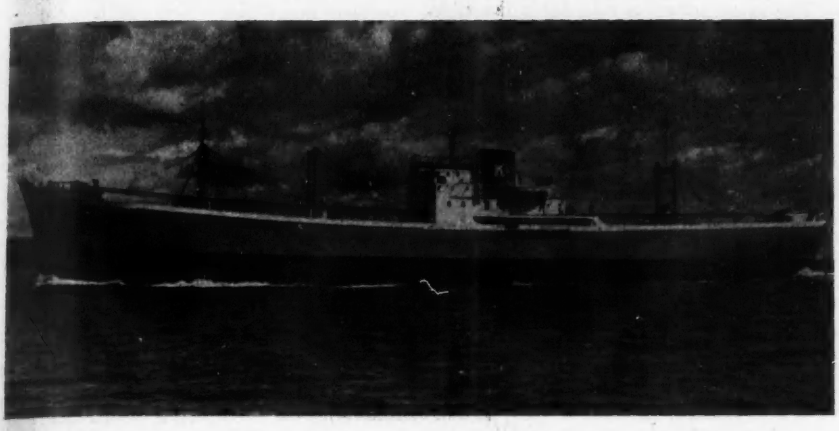


**The Caledon Shipbuilding and Engineering Company, Ltd., completed the cargo liner "Diomed" for Alfred Holt and Company. This ship has the following main particulars:—Length overall 492ft, breadth moulded 62ft, depth moulded to upper deck 35ft 3in, and a tonnage of 7984 gross. There are six cargo holds and 'tween decks, and one 70-ton, eight 10-ton and eighteen 5-ton derricks operated by electrical winches. Electrical power is provided by two 450kW diesel-driven generators, and there is one 350kW diesel-driven emergency generator. The machinery, supplied by John G. Kincaid and Co., Ltd., consists of an exhaust turbo-pressure-charged, single-acting, opposed-piston oil engine, developing 8000 b.h.p. in service at 112 r.p.m.**



**Ellerman Lines, Ltd., took delivery of the cargo liner "City of Colombo," which was built and engined by Barclay, Curle and Co., Ltd., and has a length of 470ft by 65ft 6in beam by 42ft depth to shelter deck. A deadweight of 10,500 tons is carried at a service speed of 15 knots, and there are five holds served by one 70-ton, two 12-ton, six 10-ton, four 7-ton and four 5-ton derricks. Propulsion is by a Barclay, Curle-Doxford oil engine having six cylinders of 750mm bore by 2500mm combined stroke, and power for the auxiliaries is developed by one 320kW and two 240kW diesel-driven generators. A sister ship, the "City of Winnipeg," was completed by the Caledon Shipbuilding and Engineering Company, Ltd., with propelling machinery consisting of a six-cylinder Wallsend-Doxford oil engine developing 8000 b.h.p. at 105 r.p.m.**

jected to bending and shearing forces. The college also made a study of the possibilities of employing celluloid models of ships for general strength investigations and compared the results recorded from model tests with those available from full-scale experiments on corresponding ships. With regard to the full-scale work, autographic gauges continued in operation on a number of ships and the data were collected for analysis. Static bending tests on a ship were also carried out by the staff. Ship and model scale launching investigations were continued and a report prepared upon the performance of greases at a number of launches. To assist in establishing the coefficient of starting friction of a variety of greases and lubricants a special testing frame was in course of development.



**The Tramp Chartering Corporation of Panama took delivery of the 11,750 tons deadweight open shelter deck cargo liner "Capetan Cardamilitis," which was built by the Burntisland Shipbuilding Company, Ltd. The ship has a length between perpendiculars of 445ft by 62ft 4½in beam by 41ft depth moulded to shelter deck, and a draught of 27ft 11in, and there are five main cargo holds served by ten 10-ton derricks and electric winches. Electric power and lighting are provided by three 150kW diesel-driven generators and the propelling machinery consists of a Kincaid two-cycle, single-acting diesel engine having seven cylinders of 620mm diameter by 1870mm combined stroke**

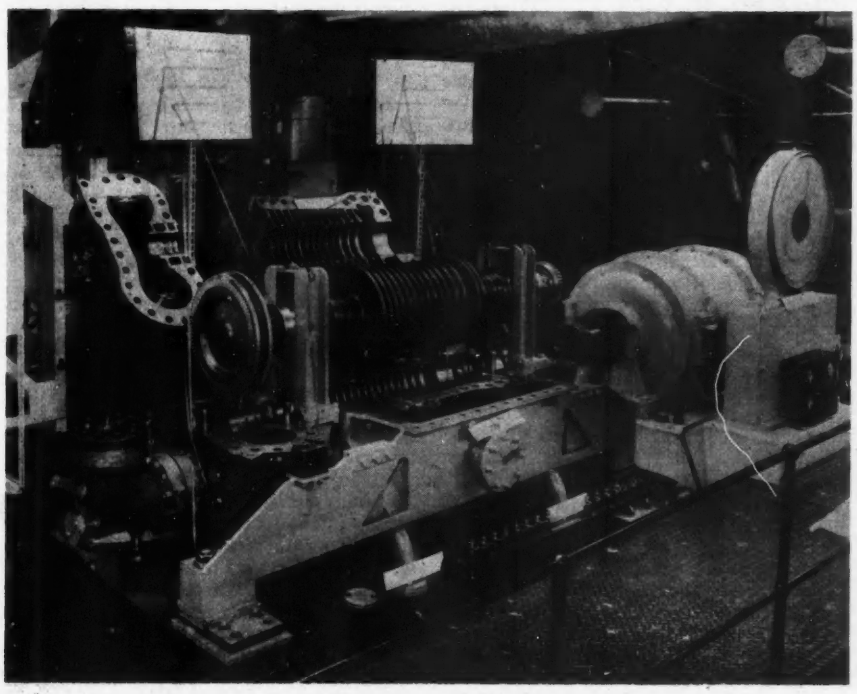
Both the testing machines at Glengarnock were fully employed, the work including the testing of a new series of deck girders and an additional bottom longitudinal specimen. Investigations into the properties and applications of the marine light alloys were continued and a technical memorandum was issued dealing with the current welding position concerning aluminium alloy plating over ⅝in thick. Development work on the welding of plate of this thickness was continued. B.S.R.A. continued its policy of supporting, and of participating in, where possible, the work of other research associations which touch upon special materials and processes, and during the year co-operated with the British Welding Research Association, the British Iron and Steel Research Association and the Aluminium Development Association. Part of the work on hydrodynamics was carried out at the St. Alban's experimental tank, of Vickers-Armstrongs, Ltd., where the new wavemaker is to be used for slamming tests.

The joint vibration investigations of the structural and machinery sections have proved of direct help to builders and owners and both theoretical and experimental approaches to the problem were pursued, including the measurement of vibration characteristics on board ship. Technical reports issued to members related to deckhouse vibration in a twin-screw passenger liner and to propeller induced exciting forces. A paper based on the Association's work and entitled "Some Observations on Local Vibration" was read before the Institution of Engineers and Shipbuilders in Scotland on November 20 by Dr. A. J. Johnson, and Mr. P. W. Ayling. Although helpful to builders and owners in curing troubles, the main purpose of the work is to establish methods of prediction which will enable troubles to be avoided at the design stage.

Technical reports were issued on a number of the items included in the ship machinery programme. The performance of rammed plastic linings was the subject of a field survey carried out jointly with the British Ceramics Research Association and a committee agreed on a programme of further laboratory and field trials on boiler refractories. Included in the work at the Royal Technical College, Glasgow, was an investigation into the principles of natural circulation in water-tube boilers using the single-tube boiler installed there. A report to members dealt with tests on the effect on natural circulation of heat input at steam pressures up to 1500 lb per square inch. Further work was planned and the necessary boiler modifications put in hand. Thermotank Ltd. has co-operated in research on the problem of keeping ships' decks free from funnel gases, the work being carried out in its wind tunnel. Two reports were published, one on the effect of superstructure design on the height of the turbulence boundary, and the other on a method of preventing the ejection of smuts by reducing funnel gas velocity. Observations to check model results were made at sea. At Imperial College a start was made to establish experimental verification of the mathematical approach employed for stressing pipelines for advanced steam conditions by stressing full-size pipe bends in a test rig.

Regarding that section of the work dealing with combustion ignition engines, it was decided that the investigations into noise should include noise from gas turbines used to drive auxiliary generators, and an investigation on board ship has been made. Work on the scavenging of two-cycle engines was continued at Vickers-Armstrongs, Ltd., while a report was issued on the steady flow tests on both full-size and model cylinder liners of the Doxford engine. The causes of crankcase explosions continued to be investigated and development continued of an oil mist detector in collaboration with the Graviner Manufacturing Company, Ltd. Work on flame suppression was started at the Buxton Safety in Mines Research Establishment in association with the Fire Research Association, and the ignition characteristics of large-size oil droplets formed another research item at Imperial College. The programme includes research on materials and a report was put in hand upon the subject of the fatigue of water-cooled mild steel diesel engine pistons. Other work was concerned with the damage caused by the presence of small amounts of sea water in the cooling water circuit, while Lloyd's at its Crawley Laboratory continued with the investigation into the effect of fillet radii on the fatigue strength of shafting.

The section of the association's programme related to the performance of both ship and machinery in service and on trial



**4000 s.h.p., double-casing h.p. turbine of Pametrada design**

continued to receive considerable attention. Many loaded trials were attended and additional data collected to assist in the work in correlating ship and model results, the model data being provided from model experiments carried out by the Ship Division of the N.P.L. The laboratory at Sunderland worked on the problems of instrumentation required for the recording of data. In addition to the above is the question of surface roughness and, to establish its effect on resistance, the association hopes to be able to arrange to run trials after the ship has been in service and compare the results with those of the acceptance trials. A report was issued upon the effect of roughness on model propeller performance.

This brief review of the work completed and put in hand during the year by the B.S.R.A. indicates that fundamental and applied research are in good balance, and that this also applies to the investigations undertaken by the staff and to those occupying the attention of various outside laboratories and the universities and technical colleges.

The latest report available from the Parsons and Marine Engineering Turbine Research and Development Association recorded the progress made under the direction of Dr. T. W. F. Brown, and noted that fourteen research reports were issued to member firms. In addition to these, nine contract reports were forwarded to the Admiralty and five to individual firms, while the staff read a number of papers before the technical institutions. Included in the report were graphs which indicated the percentage reduction in the weight of turbines and gearing since 1945, also the reduction in fuel consumption and the aggregate of shaft horsepower of steam turbines built for merchant ships to Pametrada designs. A total of ninety-six design inquiries were handled by the steam turbine department, which also provided final designs for many of these. Completions of oil tankers using steam at 850 lb per square inch and 850 deg. Fah., brought the total of such vessels built at home and abroad to twenty-nine.

Special high-temperature investigations were carried out and progress made in the basic design for a unidirectional single-cylinder turbine driving through hydraulic reverse gearing. Many acceptance trials were attended and torsional and axial vibration investigations yielded valuable design information. The first double-casing h.p. turbine of 4000 s.h.p., which is illustrated on page 61, was completed and trials run using steam at 950 deg. Fah. A design change noted was the introduction of spring-backed gland strips for both the interstage diaphragm glands and the main shaft glands, which it was felt would eliminate the occurrence of bent rotors. Progress was made in the study of pressurised boilers and, for work on heat transfer, modifications were made to a separately fired superheater which superheats steam at 1100 lb per square inch from 950 deg. to 1100 deg. Fah.

Various noise and vibration measurements were made on gearing and certain auxiliaries in naval vessels as part of the noise reduction of machinery research scheme. High temperature steam turbine trials were continued, including an overspeed test producing 25 per cent increase in normal stress. The power runs revealed that the piston valve was suitable for nozzle control at temperatures up to 1200 deg. Fah. Modification to the electric heater dryness fraction measurement system improved accuracy, and it showed that the reduction in exhaust wetness obtained with water being extracted at the three drainage belts varied between 20 to 30 per cent. Experimental evidence, resulting from a survey of steam turbine blade fatigue failures, supported the possibility of the clamped pin mode of vibration. A report on the single-stage air turbine mentioned the development of new blades which, when tested in the supersonic wind tunnel, accepted a Mach number of 1·5. Other research items touched upon in the report referred to the testing of gland strips, the progress made with the high-speed wind tunnel and the completion of the mechanical and thermal tests on a quarter-scale model of a 9000 h.p. double-casing steam turbine. These latter tests showed that vertical accelerations up to 20 *g* would not set up permanent distortion.

Reduction gear tests included the loading of a set of case hardened and ground gears to 578K in a proving run and later to the equivalent of 1350K. In the back-to-back trials, using a pinion of 3½ per cent, 40 tons to 45 tons per square inch nickel steel and a wheel rim of 35 tons to 40 tons per square inch carbon steel and a standard mineral oil, tooth breakage occurred at a loading of 488K. Journal bearing tests on light and normal oils using length/diameter ratios from ⅝ to ¼ were completed and a machine constructed to investigate the performance of water-lubricated bearings. A "Metastream" flexible coupling was reported to have run satisfactorily for 10,000,000 revolutions at 25 per cent overload with an axial extension of ¼in and a lateral misalignment of 0·050in.

A considerable amount of work was done on high-temperature, liquid-cooled gas turbines and a design study made of a unit of 10,000 s.h.p., and a maximum temperature of 2200 deg. Fah. and a pressure ratio of 16 to 1. Designs were prepared for blade cooling arrangements and also for a new method of multi-stage turbine construction. The manufacture and development of the liquid-cooled gas turbine made good progress, tests indicating that the combustion chamber and ducting are satisfactory for a gas operating temperature of 2200 deg. Fah. Work proceeded with the grinding of the silicon carbide stator blades and the filling of the rotor blades with sodium potassium alloy. An apparatus was completed for determining droplet distribution within the conical envelope of a fuel spray and a counterflow rig to obtain information on the effect of ash deposition on heat exchanger performance. Another rig was designed in which flat plate specimens of blading material can be held cantilever fashion with stresses up to 5000 lb per square inch while using air pressures of 1 lb per square inch gauge. In the liquid blade cooling programme circular tubes of various diameters and heated and cooled lengths were tested with water, mercury and sodium potassium fillings over a range of heat input rate and at rotational speeds up to 6000 r.p.m.

(*To be concluded*)

# Coal, Iron and Steel in 1956

COAL mining and iron and steel making occupy a prominent place in the essential industries of this country, for upon the success of their efforts so many other industries and services continue to depend. Coal, iron and steel are still very necessary raw materials, and, moreover, are materials which exercise a considerable influence on the world's economy. It is, therefore, by no means inappropriate, in surveying the progress of the engineering and allied industries during the past year, to consider coal, iron and steel together.

## Coal in 1956

The year just ended has been one in which the need for a greater coal production has again been stressed repeatedly. The provisional figures for the year indicate, however, that although the total output, at 222,004,000 tons, was about 500,000 tons higher than in 1955, the increase was brought about by a bigger production from opencast workings. Last year's output from the deep mines, totalling 209,929,600 tons, was 260,000 tons less than in 1955. No doubt, the National Coal Board—and the National Union of Mineworkers—having asked for more had hoped for more. But it seems unlikely that, over the next few years, coal output from the deep mines will rise much above the 1956 total.

At no time last year, however, was there any serious threat of a coal crisis. Inland consumption at approximately 217,000,000 tons was a little higher than in 1955, exports were considerably reduced, and bunker requirements were lower. Certainly, in order to meet the demands and to maintain stocks at a safe level it was again necessary for this country to import coal, but imports, fortunately, were a great deal less than in 1955. Up to December 22, coal imports totalled 5,194,700 tons, compared with 11,370,900 tons in the corresponding period of 1955. Distributed stocks of coal at the end of the year were about 19,000,000 tons, a quantity which can be considered as reasonably satisfactory.

## Manpower and Wages

One of the coal mining industry's major problems last year was manpower. On average, the total number of wage-earners at the collieries was 703,000, or about 1000 less than in 1955, but the number of face-workers, 286,200, was 3000 less. Output per manshift, however, showed a little improvement last year, although absenteeism was at a rather higher percentage than in 1955. The National Coal Board continued its recruiting efforts throughout the year, but, as its chairman, Mr. James Bowman, said in a speech at the beginning of October, the industry was "desperately short of men." At that time, he estimated that in the first nine months of the year 500,000 tons of deep-mined output had been lost by the decline in manpower. But it is encouraging to note that the losses of deep-mined tonnage on account of disputes, although still considerable, were not nearly so big last year as they were in 1955.

Negotiations over wages in the coal mining industry at no point reached a critical state last year. The wages of daymen were increased in February and there was, subsequently, a revision of the piecework wages structure. At the same time, the National Coal Board increased the salaries of its technical, administrative and clerical staffs to match salary movements in private industry. With these increases, the Board estimated some months ago that its wage and salary bill for the year would be 8 per cent higher than in 1955. The principal negotiations last year, however, were concerned with the "Miners' Charter" formulated by the

National Union of Mineworkers. One of the proposals embodied in this document is the amendment of the five-day week agreement by abolishing the payment of an extra shift's wages for working five shifts in a week, and incorporating one-fifth of the bonus payment in a new shift rate. In other words, the union is asking for the removal of the conditions attached to the payment of the five-day week bonus.

In December, the National Coal Board and the executive of the National Union of Mineworkers said that they had agreed to defer further consideration of this claim for six months. During that period, it was stated, both sides would " take such measures as they think best calculated to create the conditions " which would safeguard and improve the output position. At the same time, the Board and the union executive expressed the opinion that the " bonus disqualification clause " sometimes bears unreasonably on miners with good attendance records who occasionally miss a day's work. It was, therefore, agreed that during the six-month period mentioned there should be tried an arrangement whereby a miner with five consecutive weeks' good attendance, who misses one shift (except through a strike) in a week which is otherwise fully worked, should not lose the proportionate bonus for the days in that week on which he had worked.

When this agreement was announced a month ago, it was explained that it was subject to ratification by a coalfield vote of the union. At the time of going to press, there seems to be some uncertainty as to whether this vote, which has now been taken, supports the steps agreed by the union executive.

### Coal Prices

At the end of 1955, the National Coal Board's accumulated deficit was nearly £37,000,000. In the early months of 1956, the Board formed the opinion that, unless the price of coal was increased, the year's activities would result in a further " substantial deficit." The Board therefore decided that it must cover its full costs in 1956 and 1957, and also take steps to recover part of the accumulated deficit. Accordingly, on June 1 last, the inland price of all coal sold by the Board was increased by 8 per cent, or an average of about 6s. a ton. This increase, it was anticipated, would yield additional revenue of about £35,000,000 last year and £61,000,000 in 1957.

In announcing this price increase, the Coal Board explained that in addition to higher costs of wages and salaries, safety and welfare measures, and greater expenditure on reconstruction, there were " other costs " which had to be taken into account. It was pointed out that the rising prices of materials and services affected the Board like all other industrial concerns. Higher local rates had to be met, and there were other items such as the full effects of higher rates of national insurance. Furthermore, research on better methods of coal production and the development of new machines as well as research on smokeless fuels, all required greater expenditure, as also did education and staff training. Then, provision had to be made for the additional cost, estimated at £5,000,000 a year, of the new right to compensation for subsidence damage.

At the end of June, the National Coal Board said that unless " something quite unexpected and exceptional happened " it would not increase pithead coal prices during the ensuing twelve months. When the Board's statistics for the third quarter of 1956 were published a few weeks ago, they showed a deficit on revenue account of £1,226,411.

### Revised Plan for Coal

For the last five years or so work has been proceeding on the lines of the programme of reconstruction and development set out in *Plan for Coal*, which was published by the National Coal Board in 1950. Before the plan was produced the future prospects of something like 1000 collieries and sites for collieries were examined, and many other activities associated with colliery operation were considered. The reconstruction programme which followed this appraisal envisaged an annual output of deep-mined coal of 240,000,000 tons by 1961–65, and the capital cost of the works involved was estimated (at mid-1949 prices) at £635,000,000. Actually, between 1950 and the end of 1955 the Board's capital expenditure totalled £353,000,000.

Last April, the Board issued a " revised plan " under the title *Investing in Coal*. It emphasised that, despite the increasing use of oil, and the advent of the industrial applications of nuclear energy, the coal industry would remain for a long time yet the main source of primary fuel in Britain. It also reiterated that the National Coal Board's task was to raise coal output as high as possible in order to meet the country's increasing need for energy. But it was pointed out in the revised plan that coal mining was " not just another manufacturing industry ; it was extractive and consumed itself as it went along." The wastage of capacity at the present time, it was suggested, amounted to roughly 4,000,000 tons a year.

The Board's revised plan provides for a coal output from all sources, including opencast sites, of 228,000,000 tons in 1960 and 240,000,000 tons in 1965, the conclusion having been reached that an output of 250,000,000 tons a year cannot be achieved before 1970. To achieve the outputs estimated for 1960 and 1965, however, it will be necessary by the end of the latter year not only to complete most of the reconstruction schemes now in progress, but also to start and complete more than another hundred. In addition, it will, of course, be necessary for the Board to continue with routine plant replacements and with its mechanisation schemes. In the revised plan it is estimated that the capital cost of achieving the output figures mentioned, and of providing the money for major schemes to be completed after 1965, will be £860,000,000 for collieries and their associated activities. In addition, it is proposed to spend £140,000,000 on ancillaries.

In its revised plan, the Board drew attention to the fact that the estimates were based upon mining techniques which are already well proved. At the same time, the Board declared its determination to do everything possible to advance techniques, both those used in such operations as tunnelling and shaft sinking, which are of the highest importance in capital schemes, and those used in the getting and transporting of coal in new mines and old alike. Improvements in working conditions underground are also taken very much into account.

In Plate 4, contained in this issue, there are illustrated some of the reorganisation and modernisation schemes which were completed by the National Coal Board last year. They are representative of the many schemes which are in progress at present. Other works, of equal importance, were also completed last year. Just before Christmas, for example, a new coal preparation plant was started up at Cwm Colliery, South Wales. It is the 200th coal cleaning plant built by the Board, and is capable of handling 400 tons an hour. Among the ancillary undertakings completed last year, there is the Avenue carbonisation and chemical plant at Wingerworth, near Chesterfield. This plant, which was fully described in The Engineer of November 2 and 9, 1956, has been designed for the carbonisation of 750,000 tons of coal a year, producing 500,000 tons of coke and 5000 million cubic feet of gas. The by-products from the plant include 6,000,000 gallons of crude benzole, 13,500,000 tons of crude tar, 18,000 tons of sulphuric acid, and up to 12,000 tons of sulphate ammonia, annually. An establishment of a different kind, but of no less importance, is the Coal Board's central engineering establishment at Bretby, Derbyshire, which was described in our issue of December 21, 1956. The principal functions of this establishment are : to develop existing equipment and to design and produce prototypes of new equipment and components ; to prepare technical specifications and designs of new machines enabling alternative sources of manufacture to be exploited, and to carry out acceptance trials of equipment in the pre-production and production stages.

As well as reconstruction work in the mines, there was further development of opencast sites last year. The production of coal from the sites now being worked by the National Coal Board in Great Britain amounted to 12,074,400 tons.

### The First Decade of Nationalisation

The end of 1956 marked the completion of the first ten years of the nationalised coal mining industry. To signalise the event, the National Coal Board has published an illustrated brochure which constitutes a record of progress. A foreword to the brochure has been contributed by Mr. James Bowman, the chairman of the Board, who says that " coal has provided the nation with the resources to weather the first critical decade of the post-war world. Even in an age of oil and atomic energy, it will continue to be the mainstay of Britain's prosperity."

### Iron and Steel

Before many weeks of 1956 had passed, the British iron and steel industry had formed the conclusion that the year's output of crude steel would reach a figure of 21,300,000 tons, or 1,500,000 tons more than the output in 1955. The capacity was available, new plant continued to come into operation, and provision was made for the necessary raw materials to be forthcoming. The final figures for the year have just been issued, and they indicate that steel production in 1956 amounted to 20,660,000 tons, an increase of about 1,000,000 tons compared with 1955, but 640,000 tons below the target anticipated at the beginning of last year.

The reason for the deficiency is an unusual one for the steel industry. For many years the industry has been free from labour troubles of any serious dimensions ; its labour relations, in fact, have set a high standard. Last year, however, the activity of the steel industry was slowed down by a wages dispute which led to a ban on overtime by maintenance workers. It was that unhappy circumstance which prevented the achievement of the estimated output. The dispute hinged upon a " national procedure agreement," which provided, among other matters, for the automatic reference to arbitration of unresolved disputes. The craft unions representing the maintenance workers were anxious to have the agreement amended so that arbitration became optional, but the negotiations over the matter reached no satisfactory conclusion, and the unions

gave notice of the termination of the procedure agreement. Prior to this decision, the unions had submitted a claim for a "substantial wage increase," and early in March the employers offered a rise of 10s. a week, an amount which had been accepted by the production workers. The unions rejected the offer, and also refused to put the matter to arbitration in accordance with the terms of the procedure agreement. Instead, they imposed a ban on overtime on April 26, and early in July gave notice of strike action by the maintenance workers. That action was, however, deferred when the Minister of Labour set up a court of inquiry on July 13 to examine the circumstances of the dispute. Subsequently, at the court's suggestion, the overtime ban was lifted. But production of iron and steel during the three months May, June and July, was inevitably slowed down. There was rapid improvement, however, especially in the final quarter of the year; November was a particularly good month, an annual steel production rate of 22,172,000 tons being reached.

Pig iron production in November was at an annual rate of 13,660,000 tons, and the final figures show that the year's total amounted to 13,170,000 tons. This represents an increase of 5·6 per cent when compared with the 1955 output of 12,470,000 tons.

### Steel Supplies and Requirements

In 1955, total steel supplies amounted to 21,575,000 ingot tons, included in which there were 1,857,000 tons of imported material. Home deliveries took up 18,221,000 tons and exports 3,354,000 tons. In the first half of last year, steel consumption was about 6·4 per cent higher than in the comparable period of 1955. In the second quarter of last year, however, there were indications that home steel consumption was falling a little—it was the first decline, except for seasonal reasons, since 1952. The slackening was attributed to a lower level of activity amongst producers of motor-cars and steel consumer goods.

During the second half of last year, the change of emphasis in steel requirements became more marked. The demand for light and thin flat products eased, but there was continuing pressure for heavy products, particularly plates. Throughout the year, it must be noted, the shipbuilding industry again complained about its shortage of steel. Imports of ingots and semi-finished steel, taken over the whole year, were a little lower in 1956 than in 1955, but rather more finished material was imported. An assessment of the situation by the British Iron and Steel Federation shows that during the past year there was about 1,000,000 tons more steel available for home consumption than in the preceding year. But the Federation suggests that the rise in consumption was less than this when the increase in merchants' and consumers' stocks is taken into account.

A limited census of stocks taken on September 30 showed that in the first nine months of last year the total steel stocks held by consumers and merchants had increased by 9·7 per cent, compared with an increase of 7·1 per cent in 1955 and an average post-war increase of 4·4 per cent a year. The figures provided for this census by consumers indicated that stocks of sheet increased by 7 per cent in the first nine months of last year, compared with an increase of 47 per cent in 1955. On the other hand, stocks of plate increased by 14 per cent, compared with a decline of 3 per cent in 1955. The comment made about this by the Iron and Steel Board was that the building up of plate stocks illustrates the known tendency of steel consumers to endeavour to increase their stocks during times of active demand.

### Iron and Steel Prices

There were two general price increases in most iron and steel products in the United Kingdom during 1956. The first of them, which was made on May 7, had the overall effect of raising the average level of prices by 5 per cent. In announcing the increases, the Iron and Steel Board explained that, for the most part, they were necessitated by the higher cost of imported materials and of home produced scrap. There were other increased costs which had to be faced by the iron and steel industry, particularly those resulting from higher wage rates and from the increase in railway freight charges, authorised early last year. Those increases were not, however, included in the 5 per cent addition to iron and steel prices made in May, although the Iron and Steel Board indicated that the extent to which the iron and steel industry would be able to continue to carry the extra costs of wages and railway charges would be "kept under review." At the same time, the Board pointed out that, even with the increases authorised, the prices of iron and steel products in the United Kingdom market remained about 10 per cent below those of most other steel producing countries.

The second price increase last year came on December 17. The price changes made then represented an average of 6 per cent on existing prices. In the case of most iron and steel products the actual increase was rather less than that, but in a few instances, such as plates, heavy sections and some foundry pig iron, the Iron and Steel Board claimed that a review of the price structure had established the need for an increase of more than 6 per cent "in the interests of economic development." In the latest price increases, no allowance was made for such rise in costs as may have arisen from the repercussions of the Middle East situation or the continued hardening in the cost of imported materials and ocean freights. The Iron and Steel Board stated that it had made a comprehensive review of the price structure in relation to operating and capital costs, the greater capital now employed in the industry, and the programme of current and future development. The latest price changes reflect the substantial increase in production costs and some adjustment of margins. Steel prices in most of the producing countries were advanced last year. Although it is not easy to make an exact comparison between individual countries and products, the Iron and Steel Board believes that the prices now ruling in the United Kingdom are about 8 per cent below those of Western Europe generally.

### The Steel Industry's Development Programme

Work on the iron and steel industry's second development plan continued throughout last year, although the progress made was perhaps rather less than had been anticipated. It is estimated that the work actually completed in 1956 cost about £80,000,000, or £25,000,000 below the original estimates made by the companies concerned. The deficit must be attributed to construction delays, but the work outstanding will be added to the expenditure of £105,000,000 planned for this year. The iron and steel industry's expenditure on fixed assets in the post-war years is more than noteworthy! By the end of last year, it had reached a figure of £550,000,000, or £710,000,000 if calculated at present-day prices.

We do not review in any detail here the many projects completed or in progress in 1956. One or two of them are illustrated in Plate 5, and are sufficient to give some idea of the kind of development and expansion schemes which are being undertaken in all the steel-making districts of Great Britain. In a general consideration of the industry's development plans, however, it is well to bear in mind that, as recently emphasised again by the British Iron and Steel Federation, there is no longer reliance on scrap as the main steel-making material. Since the war, rapidly increasing steel production has outrun scrap supplies, and the industry has been forced to increase its use of pig iron in steel-making; the pig iron-scrap ratio, in fact, has moved from about 4 : 5 in 1937–38 to 1 : 1 at the present time. The industry, therefore, has not only had to increase plant capacity at all stages in line with the expansion of steel demand, but it has also been compelled to embark on a relatively greater expansion of blast furnace capacity. That in its turn has involved more coke ovens, more ore preparation and sinter plants, more ore-handling and transport facilities, and specially-designed ore carriers.

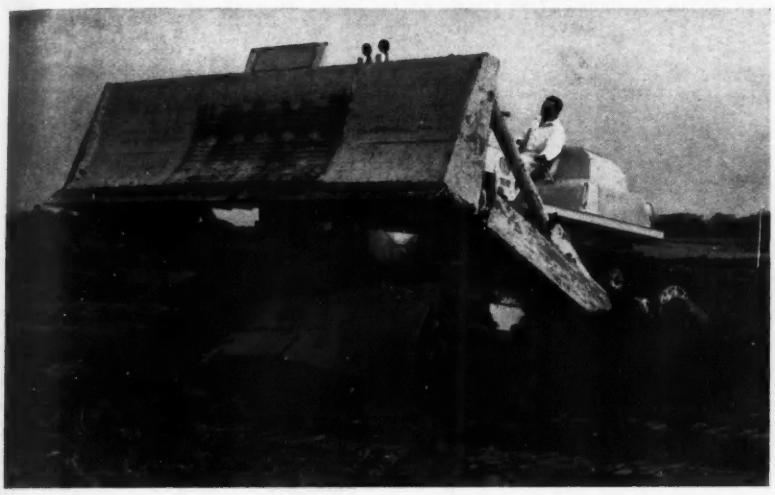
With the blast furnace, steel melting, and steel finishing capacity expected to be in commission this year, production might well increase by a further 1,500,000 tons. But in its assessment of the 1957 situation, the British Iron and Steel Federation is wisely cautious. Before the end of last year, of course, there was considerable uncertainty about the extent and duration of cuts in oil fuel supplies. The steel industry is by far the largest consumer of fuel oil and nearly 8,000,000 tons of steel a year are produced in oil-fired furnaces. In addition, many soaking pits, reheating furnaces and finishing facilities depend on oil, even where the steel itself is produced with other fuels, or, as in the case of the Bessemer process, with none.

Possibilities of substitution of solid fuels are strictly limited by the design of furnaces, the equipment available and contracts for the supply of gas to outside consumers. The effect of any cut in supplies of oil fuel will therefore depend essentially on the additional amount of other liquid fuels—tar or creosote pitch—which can be made available. These are desirable fuels, of which the iron and steel industry is already using some 650,000 tons a year. But the additional supply required to make good a cut of 10 per cent in fuel oil represents an increase of over 25 per cent in the industry's consumption of these fuels. Steel output this year, however, is bound to be affected both by the restriction of the total supply of liquid fuel and by the adjustments necessary to achieve the desired substitutions. Nor, the British Iron and Steel Federation suggests, is this the end of the story. To reach the desired level of output by the industry in 1957, nearly 100,000,000 tons of material and products would have to be moved. The industry is, therefore, particularly affected by transport cuts. Restricted movement within the works because of cuts in diesel oil supplies and reductions of outside transport are equally important.

In present circumstances, therefore, no reliable estimate can be made of steel production in 1957. But the final word is that, if circumstances had been different and an output of 22,250,000 tons had been in prospect, so large an increase in steel production must prompt the question whether the prospective level of demand would be likely to be able to support it!

# HEAVY EARTH-MOVING PLANT

At the Acorn Bank opencast coal site in Northumberland, Costain Mining, Ltd., has built a private road for the 1½-mile journey to the coal preparation plant, along which coal is hauled at 30 m.p.h. by tractor and trailer vehicles (right). Eight bottom-dump semi-trailers and four tractors are to be used. The tractor is an adapted Euclid vehicle of 270 h.p. The semi-trailers are built by the Eagle Engineering Company, Ltd. Each of them has a capacity of 60 cubic yards, and can be emptied in seventeen seconds by bottom-opening doors

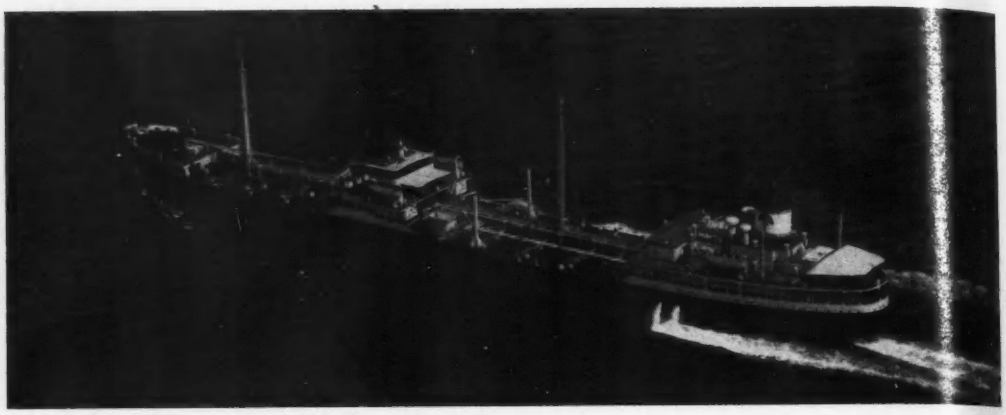


Steering and suspension problems have been simplified in the Euclid "Twin-power Crawler" by dividing the vehicle into two, each hull having its own engine and a track rigidly attached to it. The two ahead/reverse selectors are seen under the driver's left hand. The halves pivot about a transverse shaft immediately in front of the driving sprockets; the guide defining the relative movement can be seen across the front. Each engine is a six-cylinder G.M. two-stroke with Roots blower, and a total of 365 h.p. is available through the "Torqmatic" transmissions. The tractor weighs 25 tons dry; it can attain 8·3 m.p.h. and an effort of 37 tons at 1 m.p.h.

The walking dragline illustrated below is now in service at the Scunthorpe opencast mines of the United Steel Companies, Ltd., and was designed and built by Ransomes and Rapier, Ltd. It has a maximum capacity of 12 cubic yards at 165ft radius with alternative capacities of 8 cubic yards at 201ft and 10 cubic yards at 184ft. A point of particular interest in this machine is that its heaviest member weighs 24 tons, and it is assembled with fitted bolts throughout so that it can be dismantled when work is completed at one site, and transported to another site for re-erection (see "The Engineer," August 24, 1956)

# LARGE OIL TANKERS

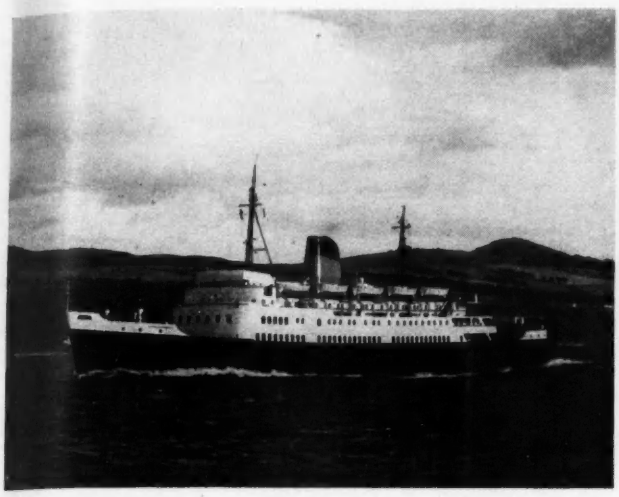
On the right is the "San Felipe," built by Smith's Dock Company, Ltd., for the Eagle Tanker Company, Ltd., and which is the second vessel of three ordered by the owners, the first ship being the "San Fabian." The tanker carries a deadweight of 18,217 tons on a draught of 29ft 10in, and the following dimensions: length between perpendiculars 530ft, breadth 69ft 3in, and depth 39ft. Hawthorn Leslie (Engineers), Ltd., supplied the double reduction geared turbine machinery and boilers



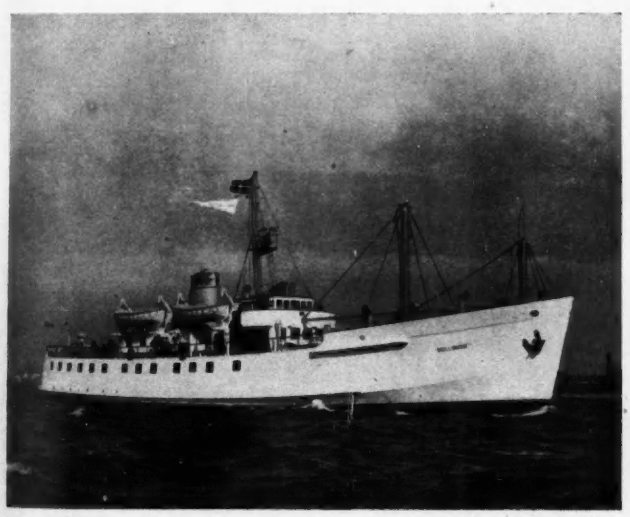
Shown below is the "Caltex Edinburgh," built and engined by Scott's Shipbuilding and Engineering Company, Ltd., for Overseas Tankship (U.K.), Ltd. The main particulars are: length between perpendiculars 530ft, breadth 71ft, depth 39ft 9in, deadweight 18,255 tons on 30ft 1½in draught, and service speed 15 knots. A total of 7500 s.h.p. is developed by a set of compound double reduction geared turbines taking steam at 600 lb per square inch and 950 deg. Fah. from two Foster Wheeler boilers. Three 650 tons per hour pumps handle the oil cargo

Below is the 47,750 tons deadweight tanker "Spyros Niarchos," built and engined by Vickers-Armstrongs (Shipbuilders), Ltd., at Barrow, for the Neptune Tanker Corporation. The ship has a length overall of 757ft by 97ft 2in breadth by 52ft depth, a maximum draught of 37ft 9in and a sea speed of 17 knots, given by a single set of geared turbines of 18,000 s.h.p., taking steam at 600 lb per square inch and 860 deg. Fah. from three Foster Wheeler boilers

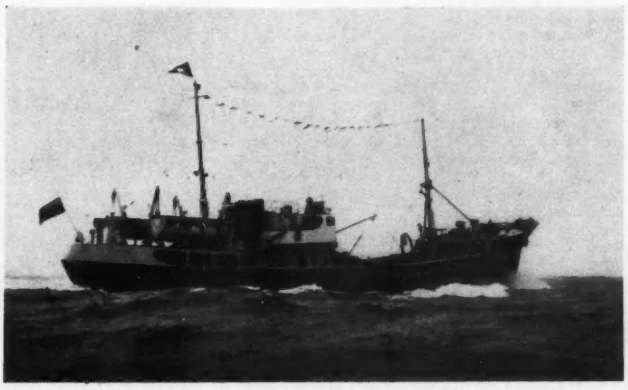
# CROSS-CHANNEL AND SMALLER CRAFT



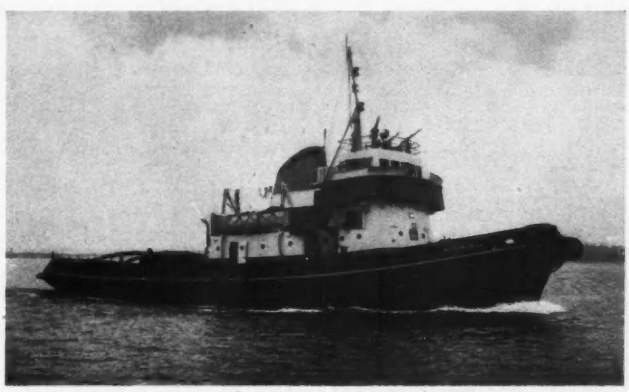
The " Duke of Lancaster " was built and engined at Belfast by Harland and Wolff, Ltd., for the Heysham-Belfast service of British Railways. A total of 600 first and 1200 second-class passengers are carried, and cabins are provided for 240 first-class and 216 second-class passengers. The ship has a length overall of 375ft, a length between perpendiculars of 354ft, a breadth moulded of 55ft, a depth moulded to main deck of 19ft 6in, and a tonnage of 5075 gross. A service speed of 21 knots is maintained by two sets of turbines which develop a total of 10,500 s.h.p. when driving twin screws at 225 r.p.m. through locked-train articulated double-reduction gearing. Steam is generated at 350 lb per square inch and 700 deg. Fah. in two Babcock and Wilcox integral furnace boilers. The auxiliary machinery is mainly electrically driven and the necessary power is developed by three Allen 240kW diesel-driven generators. The same builders completed a sister ship, the " Duke of Argyll," and William Denny and Brothers, Ltd., built and engined a third ship, the " Duke of Rothesay " during the year



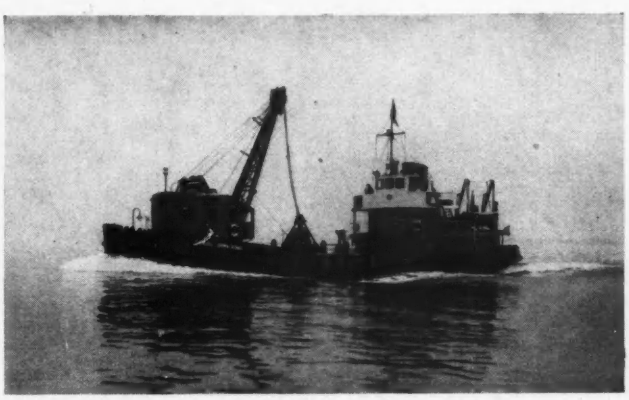
The " Scillonian " was built and engined by John I. Thornycroft and Co., Ltd., for the mainland to the Scilly Isles passenger and cargo service of the Isles of Scilly Steamship Company. The new ship has a length overall of 208ft 6in by 30ft 9in moulded breadth by 13ft 9in depth to main deck and 21ft 3in depth to promenade deck. The tonnage is 930 gross and the ship, which attained a speed of 15·5 knots on trial, has accommodation for 500 passengers, while two large holds and 'tween decks forward have a cargo capacity of 26,000 cubic feet. For propulsion there are two Ruston and Hornsby Mark 6 V.G.B.X.M. vertical pressure-charged, four-stroke, airless injection, cold starting, uni-directional diesel engines having six cylinders of 12·5in bore by 15in stroke. Each engine develops 720 b.h.p. at 430 r.p.m. and drives a propeller at 222 r.p.m. through a Modern Wheel Drive oil-operated reverse reduction gear, and delivers 670 h.p. to the propeller shaft. Two 35kW diesel-driven generating sets supply the electrical power required



The " Pioner " is the first of twenty trawlers ordered from Brooke Marine, Ltd., for the U.S.S.R. The ship has a length between perpendiculars of 171ft 9in by 32ft breadth moulded by 16ft depth moulded, and is powered by a Mirrlees Mark K.S.S.D.M. eight-cylinder, four-stroke, single-acting, airless injection, turbo-charged direct-reversing oil engine, developing 950 s.h.p. and 1100 s.h.p. at 255 r.p.m. and 265 r.p.m., respectively. Two fish holds have a capacity of 14,830 cubic feet and the trawl winch has a capacity of 1200 fathoms of 3in wire rope, and is powered by 146kW generator. Other electric power is supplied by two 50kW generators and one 18kW unit



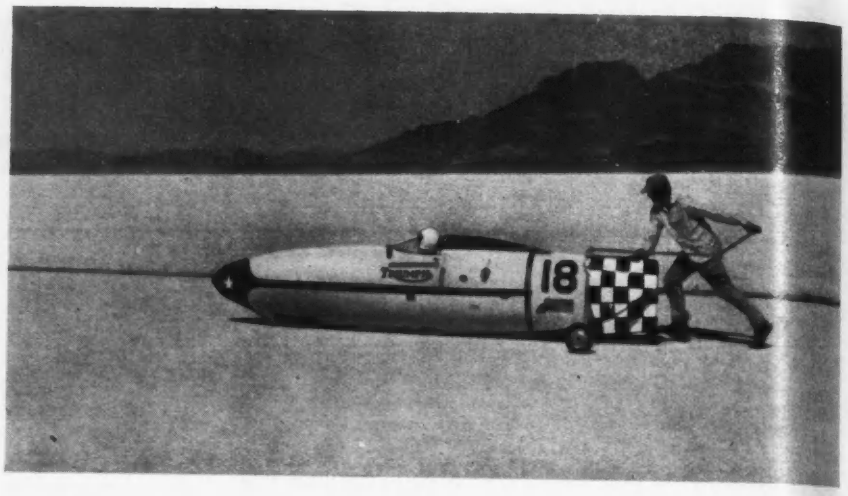
The twin screw tug " Atherfield " was delivered to the Southampton, Isle of Wight and South of England Royal Mail Steam Packet Company, Ltd., from the Woolston yard of John I. Thornycroft and Co., Ltd. Designed primarily for handling tankers at the Fawley refinery, the tug is fitted with extensive fire-fighting equipment. The main particulars are : length between perpendiculars, 100ft ; breadth moulded, 27ft ; draught amidships, 9ft 9in ; draught maximum, 11ft 11in ; tonnage, 253 gross ; static bollard pull, 17·75 tons ; trial speed, 11·78 knots. The ship is propelled by two Crossley two-stroke, uni-directional diesel engines having six cylinders of 10½in bore by 13½in stroke, developing collectively 1340 b.h.p. at 500 r.p.m., and driving through oil-operated reverse reduction gears

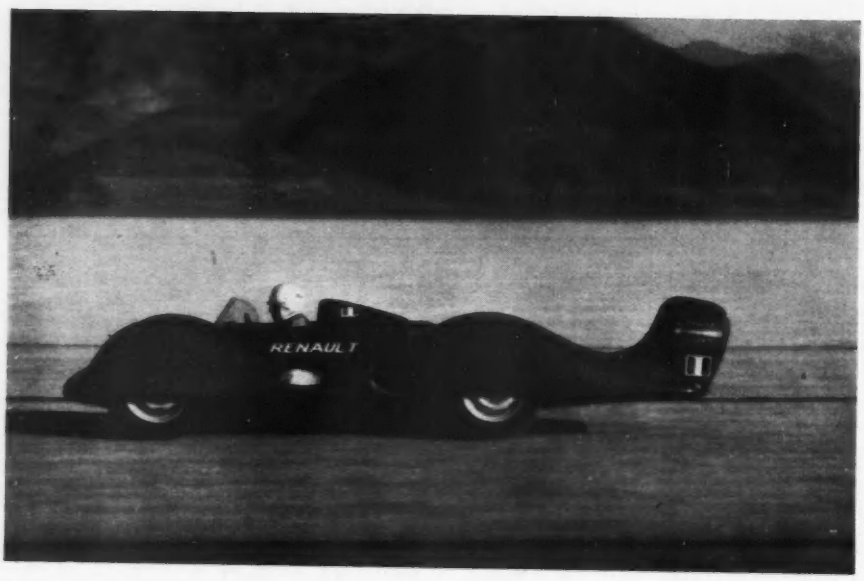


Henry Robb, Ltd., built the grab hopper dredger " Samuel Armstrong " for the Ipswich Dock Commission, for service at the docks and on the River Orwell. The vessel is designed for a hopper capacity of 300 cubic yards on a mean draught of 10ft 6in and has the following dimensions : length overall, 135ft ; breadth moulded, 28ft 6in; and depth moulded to upper deck, 12ft. For dredging operations there is a diesel grab dredging crane having a grabbing radius of 30ft, a working depth of 50ft below water level and equipped with a 70 cubic foot mud grab and a 55 cubic foot sand grab. A Crossley two-stroke diesel engine of 700 b.h.p. at 350 r.p.m. gives the dredger a loaded speed of 10 knots

# SPEED RECORDS OF THE YEAR

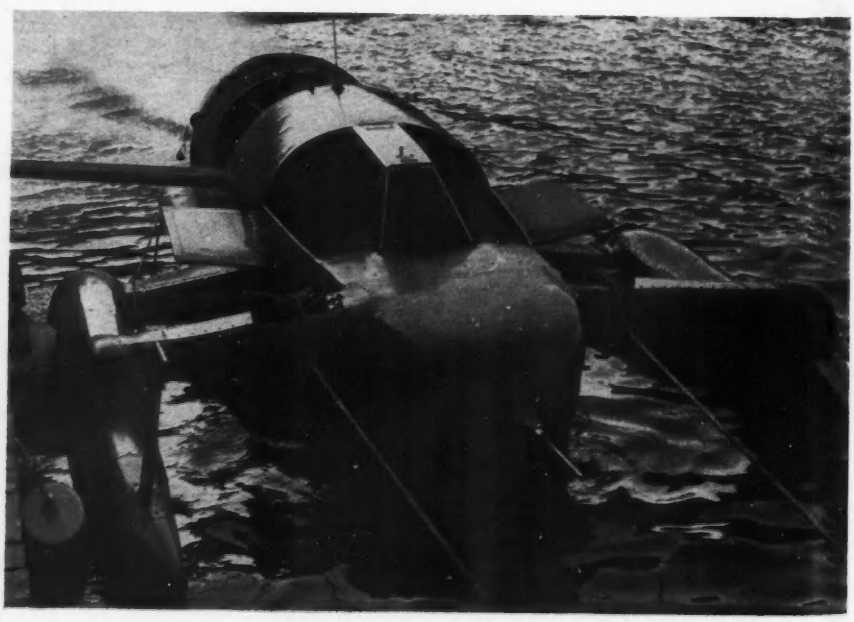
On September 6 the month-old world speed record of the supercharged N.S.U. motor-cycle was broken by the machine seen here. It has a 650 c.c. Triumph "Thunderbird" engine, which with duplicated Amal carburetters, and running on 80 per cent methanol and 20 per cent nitromethane yields over 80 b.h.p. Engine speeds up to 7000 r.p.m. were used in the record attempt with a final drive of 2·33. The cycle is 12ft long; its frame is of alloy steel tubing, with the front wheel mounted in a heavily raked unsprung fork. The rider is seated low down in the machine, steering by handlebars through a long drag link. The engine is immediately behind him; one of the exhaust stubs can be seen protruding through the streamline shell. At the extreme rear of the shell are mounted 28in and 48in braking parachutes, both to arrest the machine if it falls over and for normal stops below 100 m.p.h. The fairing is 15ft long but less than 3ft high, made of resin-bonded glass fibre. The wheelbase is 9ft 4in and the weight, without rider, no more than 320 lb, including ballast in the nose to give an approximately equal weight distribution. The record established was 214·40 m.p.h. over 1 mile



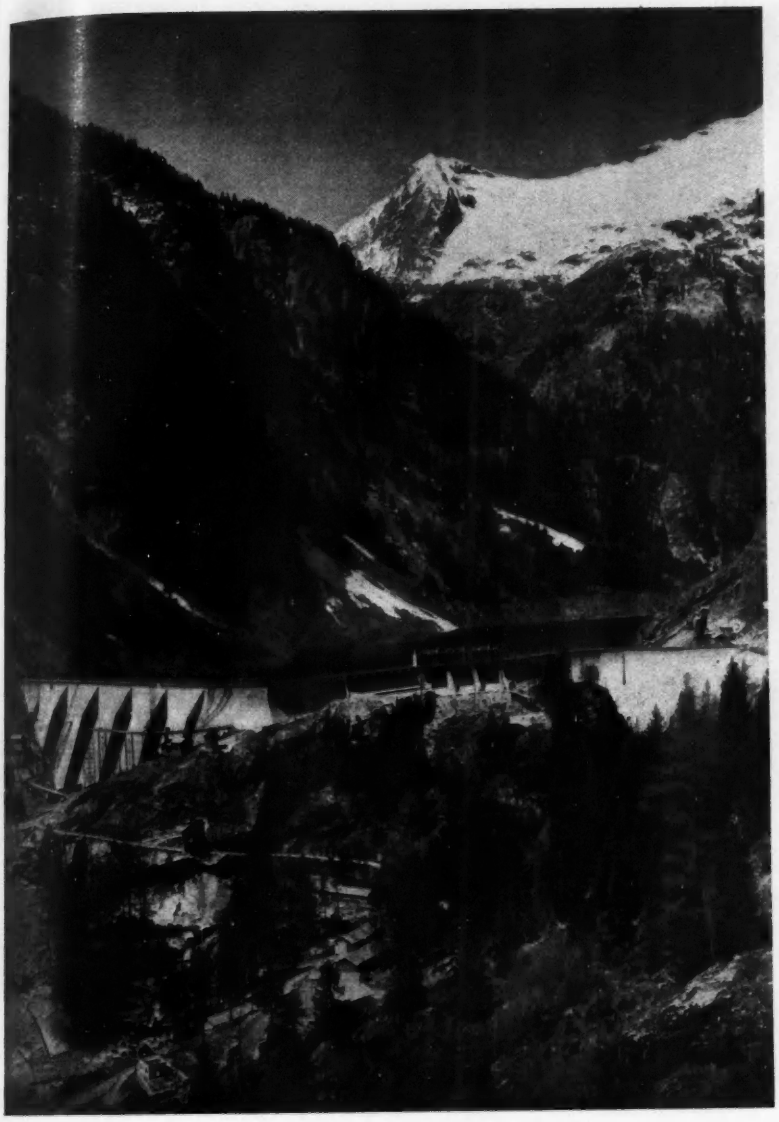



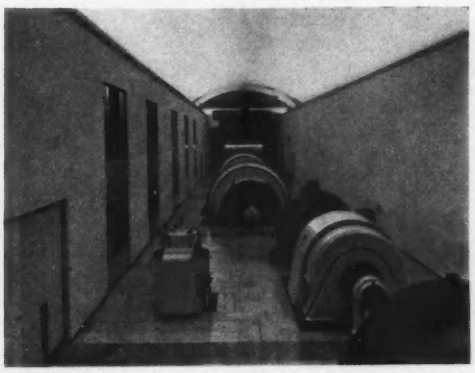

Also seen in action on the Bonneville Salt Flats is the Renault "Etoile Filante" establishing a speed record for gas turbine vehicles of 192 m.p.h. A Turbomeca "Turmo" 1 is used, distinguished by its annular combustion chamber fed with fuel through drillings in the main shaft, which runs at 35,000 r.p.m. From the free turbine 270 h.p. is taken at 28,000 r.p.m., the final drive reducing this speed to 2500 r.p.m. The car follows accepted high performance design, with a tubular space frame carrying an aerodynamic shell; conspicuous are the twin fins. All wheels are independently sprung and the inboard brakes are discs. The engine is immediately behind the driver in the centre of the car, and the air intake and gas exhaust openings can be seen in the side of the car

The world's water speed record has been increased successively on several occasions by Mr. D. Campbell in the "Bluebird," illustrated here. The present record was achieved on September 19 last on Lake Coniston, when an average speed of 225·63 m.p.h. was recorded. However, on one of the two record runs the speed was 287 m.p.h. "Bluebird" is a three-point hydroplane, with two planing surfaces forward and one aft; each surface has an area of about half a square foot in contact with the water when the boat is travelling at speed. Her length and beam are approximately 26ft and 10ft 6in, respectively, and she is powered by a Metropolitan-Vickers "Beryl" gas turbine, giving about 3700 lb static thrust at sea level. "Bluebird" was designed by Norris Brothers, Ltd.; her main frame was built by Accles and Pollock, Ltd., and various other firms were concerned with the assembly work



# ALPINE WATER POWER



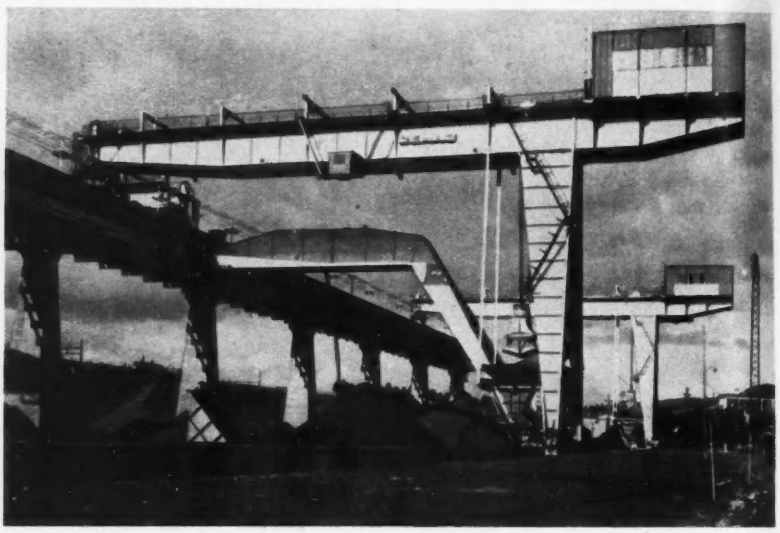


The main works of the Maggia power scheme are now virtually complete, apart from the diversion of the River Bavona from S. Carlo to Piano di Peccia, and the doubling of the capacity of Cavergno, by adding two more sets, to bring it to 110MW. A description of this 800 million kWh per annum Swiss scheme will be found in "The Engineer," June 25, 1954. Top, right, is the underground station at Peccia, which has two twin horizontal Pelton sets, each 23·5MW/12kV, 7·25 cumecs/300 r.p.m., with a gross head of 426m. In addition, there are two 11MW pump sets for 2·25 cumecs each and a 400m head. Verbano underground power station, beside Lago Maggiore (above) operates with a head of 293m and has four vertical Francis sets, each for 25·15MW/12kV, and 11 cumecs/600 r.p.m.

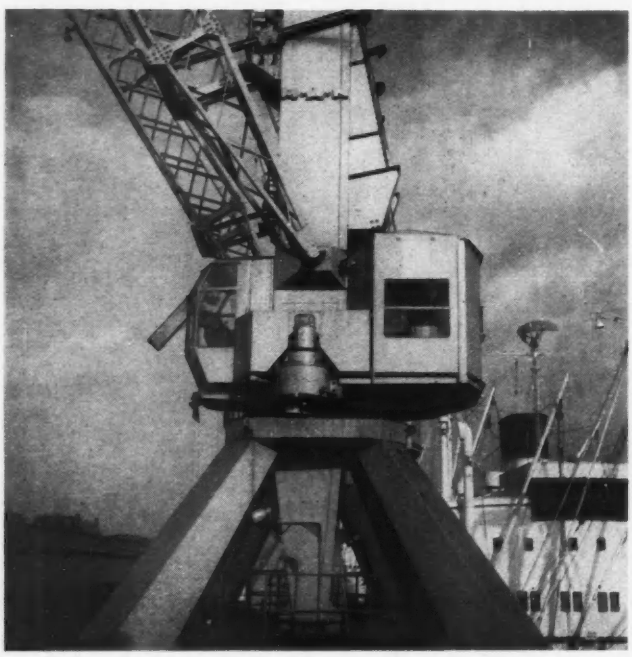
Italian hydro-electric resources are estimated to total 45,000 million kWh, of which in 1955 over 31,000 million kWh—the highest proportion for any country—were already being exploited. Our illustration (above) shows the Malga Bissina dam and reservoir which form part of the power development on the Alto Chiese River (Società Edison, Milan). The water from this reservoir, which holds 60,000,000 cubic metres, is used in the power stations at Boazzo and Cimego. From the point of view of technical progress, the Italian power industry has many pioneering achievements to its credit, such as, for instance, the first European power station, S. Radegonda (Milan), which opened in 1883. On the right are shown the two main sets for the Cimego power station, which are powered by the largest horizontal Pelton turbines built to date. Each alternator has a capacity of 110MW and is driven by two turbines, one at each end. The water comes from the main diversions from Malga Boazzo. In addition, the station has a vertical Francis set of 9·2MW, supplied from the Ponte Murandin diversion. The alternator of each of the main sets weighs about 650 tons, and the rotor complete with poles, 370 tons. Because of these weights, assembly had to be carried out at the site. The station produces about 414 million kWh in the mean hydrological year

# GERMAN STRUCTURAL STEELWORK

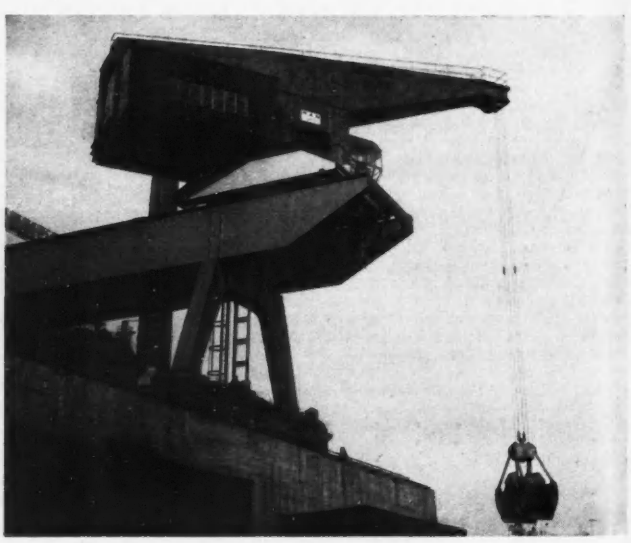
The steel frame of the fourteen-storey Federal Statistical Office, Wiesbaden (left), was completed within five and a half months from receipt of order by Fried. Krupp Maschinen und Stahlbau Rheinhausen and associates. The building measures 96·8m by 19·92m by 50m high. Columns are spaced with a pitch of 5m along the length, and at centre distances (5·53m+8·27m+5·53m) along the width, two expansion joints being provided at columns Nos. 6 and 13. On all floors two corridors, each 2215mm wide, run along the whole of the building to the inside of the inner rows of columns; the outside floor space is devoted to offices (floor loading 500 kg per square metre), and the centre to the archives (floor loading 1000kg per square metre). A specific weight of not quite 17 kg per cubic metre was achieved. This low weight and the competitive construction are stated to be due to the use of high-tensile steel (except for the floor beams), a design which minimised machining, use of steel-mesh-reinforced continuous floor slabs (low shuttering costs), and use of "Vermiculite" cement or "Vermiculite" plaster trowelled on expanded metal, for protecting the steel components from fire, in place of the usual concrete



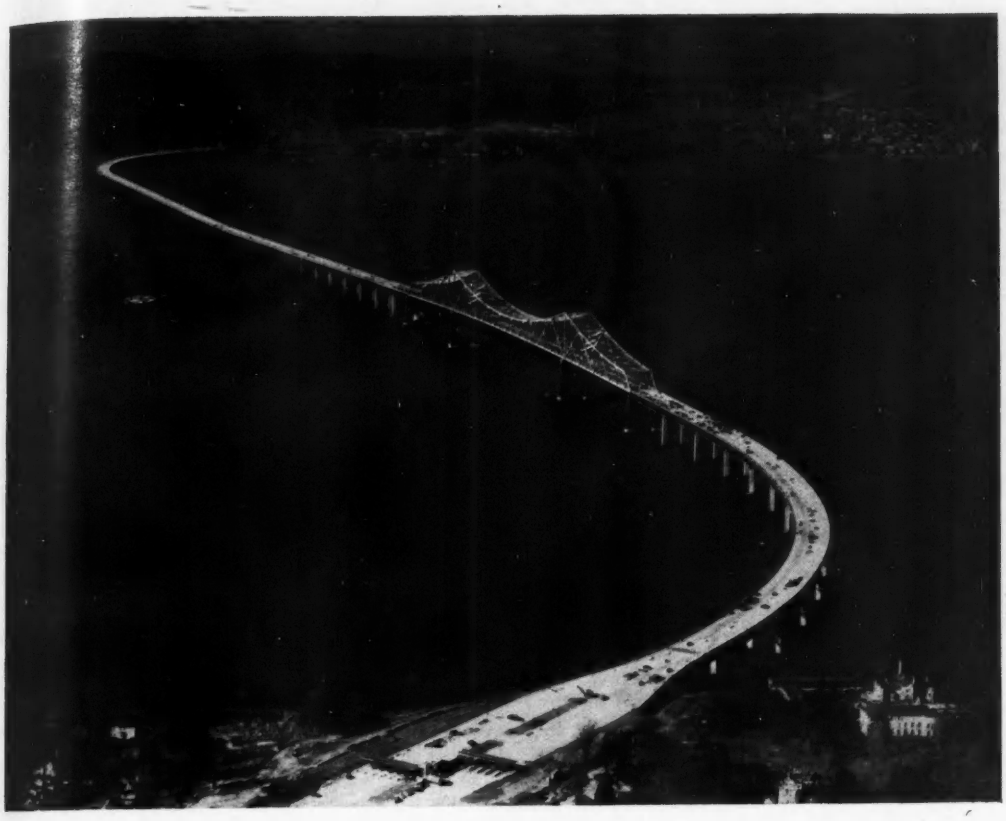
The ice-free port of Narvik handles a large proportion of all Lappland iron ores, including almost all the ore from Kiruna the annual total being about 9,000,000 tons. New ore-handling facilities were recently completed by Demag A.G. (Duisburg) after five years' work. Since rail transport of the various grades of ore cannot be directly matched to current shipping requirements, a large stocking area, holding 2,400,000 tons and capable of extension to 3,500,000 tons, has been provided. After unloading and crushing to size the ore is stocked out by four travelling conveyor bridges which receive it from a central overhead system of belt conveyors. Our illustration (right) shows one of these conveyor bridges, stationed between two of the four travelling bridges which remove ore by means of grabs and transfer it via bunkers on the bridge supports to conveyors (foreground, roofed over) which lead to the pier. The system allows the iron and phosphorus content of the shipments to be adjusted by mixing different grades of ore, and has a stocking capacity of 4000 tons per hour, with the same capacity for ore removal



The left-hand illustration shows a 3-ton portal crane with a radius of 25/7m. At the foot of the superstructure is the slewing gear. The transporter shown below is of open-box design, with a 12·5-ton slewing crane. The bridge has a span of 25·3m, with cantilevered ends 7m and 10m long respectively. Both cranes were built by M.A.N.



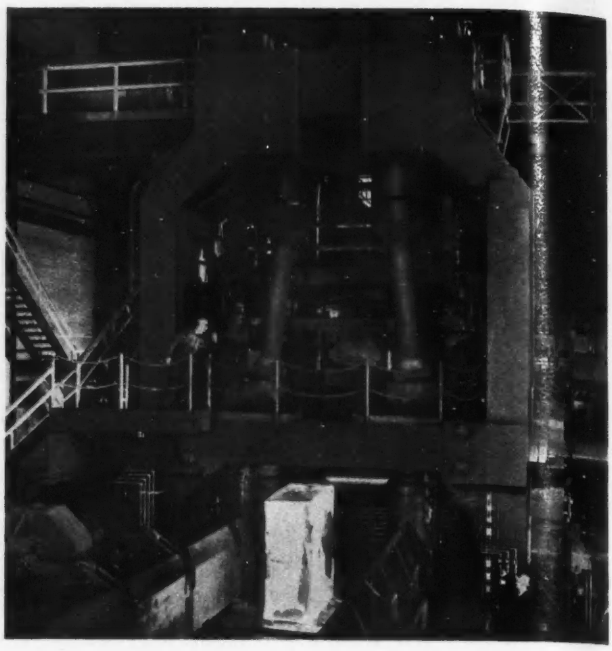
# BRIDGE CONSTRUCTION IN THE UNITED STATES



The 2·8-mile-long New York State "Thruway" or Tappan Zee Bridge crossing the Hudson River between Tarrytown and South Nyack, New York, was completed early in 1956. The structure, which carries the New York State "Thruway" across an extremely wide reach of the river, comprises a main channel cantilever bridge, 1212ft long, with two 602ft long anchor spans. The approach spans of the six-lane bridge are supported on cofferdam piers spaced 235ft to 250ft apart. An interesting aspect of the main pier construction was the use of buoyant concrete boxes, with piles up to 295ft long, driven through these boxes at the bridge site. The bridge superstructure was fabricated and erected by the American Bridge Division of the United States Steel Corporation

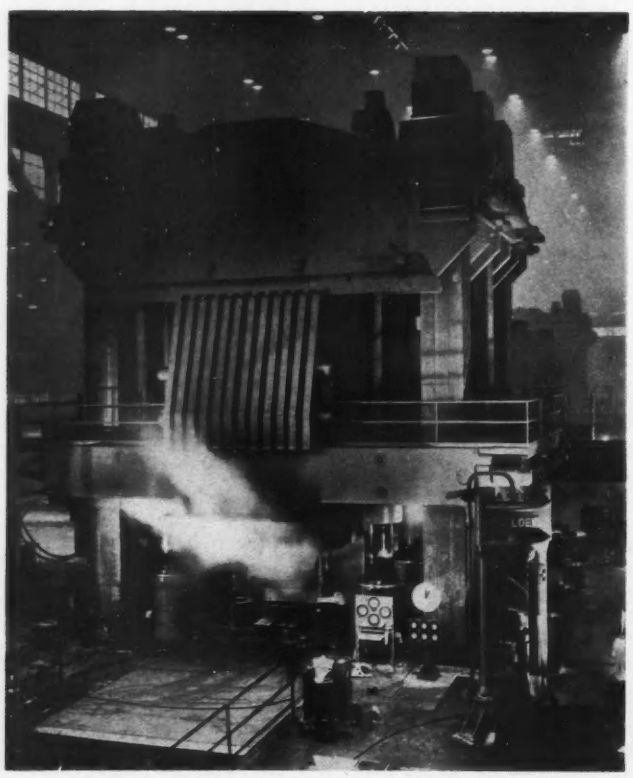
The Richmond-San Rafael Bridge connecting the towns of Richmond and San Rafael across the northern part of the San Francisco Bay in California, was opened to highway traffic on September 1, 1956. The main structure has a length of 21,343ft and the bridge is believed to be the second longest bridge in the world, being exceeded only by the 22,720ft long San Francisco-Oakland Bay Bridge. A main and a secondary channel are each spanned by a cantilever bridge structure, with, in each case, a 1070ft main span and two 535ft anchor spans; vertical clearances above the channels are 185ft and 135ft, respectively. At present, only the upper deck, with its three 12ft traffic lanes, is open; the lower deck will be completed in 1957. The bridge superstructure was fabricated and erected jointly by the Judson Pacific-Murphy Corporation and the Peter Kiewit Sons Company

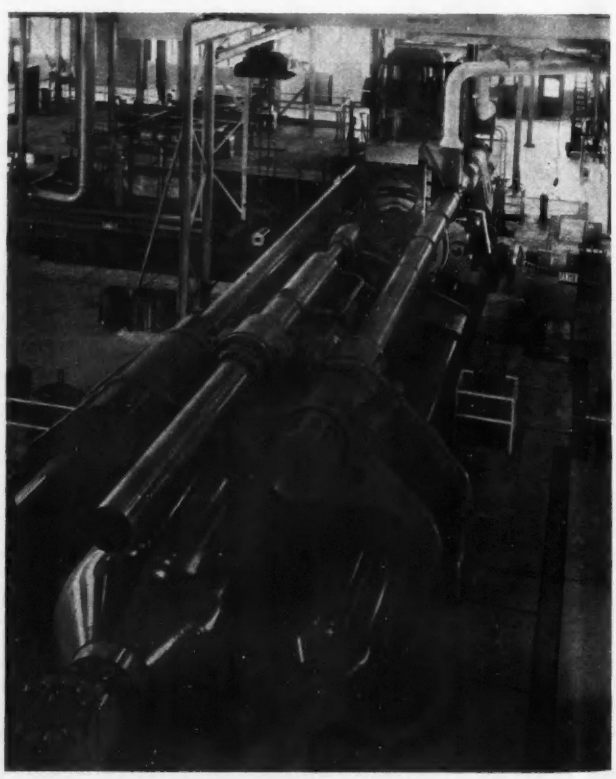
# AMERICAN ROLLING MILL AND HEAVY PRESS INSTALLATIONS



The latest American installation for the production of broad-flanged beams went into operation during 1956 at the Indiana Harbor Works of the Inland Steel Company. In rolling such beams up to 24in deep, a bloom is produced on a 32in break-down mill, passes to a 28in roughing stand, from which a travelling table transfers it to the 44in universal structural mill shown above left. It then passes through a 34in edger and on to a 40in finishing mill. Both the beam mill and the edging mill have an automatic preset screwdown system, thus freeing the operator from manual operation of these controls. Both the 44in beam mill and the 34in edger are operated in tandem by one operator. The 45in universal slabbing mill (upper right), which recently went into operation at the Ecorse Works of the Great Lakes Steel Corporation, is another one of the most powerful rolling mills in the United States. It, too, has 45in by 90in main rolls and 37in by 96in vertical rolls. The mill is also driven by a 16,000 h.p. reversing drive consisting of a 6000 h.p. double-armature motor on each horizontal roll and a 4000 h.p. double-armature motor on the vertical rolls. The mill drive has been set to give a base speed reversal time of 1·5 seconds, and the maximum roll speed is 825ft per minute

Several major forging and extrusion units of the U.S. Air Force heavy press programme went into operation during 1956. The original programme called for the construction and operation of seventeen units, both extrusion and forging presses. This was reduced to ten units ; six extrusion presses and four forging presses. The lower illustration on the left shows the 50,000-ton closed die forging press in operation at the Wyman-Gordon Company in North Grafton, Massachusetts, which is believed to be the largest press in the world. The machine stands 50ft above the operating floor, descends 60ft below it, and is suspended in a 100ft deep pit. Each of the six columns of the press is made of three identical 110ft long forged steel sections. The entire press weighs about 10,000 tons. It produces aluminium and magnesium alloy forgings. The lower right illustration shows the 12,000-ton hydraulic extrusion press of the Curtiss-Wright Corporation in Buffalo. This 126ft long machine was designed for the extrusion of carbon, alloy and stainless steels and of titanium alloys. A 50ft long tube, 6in in diameter, is extruded in nine seconds, and one thousand feet of ½in spring steel rod in three seconds. Both of these machines were designed and built by the Baldwin-Lima-Hamilton Corporation





# Naval Construction in 1956

By RAYMOND V. B. BLACKMAN

No. II—(*Continued from page 31, January 4*)

IN addition to the ships of the post-war rearmament programme, described in Part I of this article last week, there are still in the course of construction six large warships which constitute the back-log of the second world war emergency building programme. Of these the largest is the aircraft carrier "Hermes," which was laid down as long ago as June 21, 1944. After the war her construction was not pressed and it was not until February 16, 1953, that she was launched from the Barrow-in-Furness yard of Vickers-Armstrongs, Ltd. Since then her design has been entirely recast, and her armament is under review, but no structural work on her appears to have been done since she took the water. Work is still suspended on the remaining two light fleet aircraft carriers.

The construction of the long-suspended three cruisers of the new "Tiger" class was resumed in 1956 after having been stopped since the end of the second world war. The "Tiger," laid down as long ago as October 1, 1941, and launched on October 25, 1945, is being completed by John Brown and Co., Ltd., Clydebank, the original builders, and the "Blake," laid down on August 17, 1942, and launched on December 20, 1945, is being resumed by the Fairfield Shipbuilding and Engineering Company, Ltd., Govan, Glasgow, her initial contractors; but the "Defence," laid down on June 24, 1942, and launched on September 2, 1944, is being completed by Swan, Hunter and Wigham Richardson, Ltd., Wallsend-on-Tyne (Scotts' Shipbuilding and Engineering Company, Ltd., Greenock, built her to the launching stage), with main machinery manufactured by the Wallsend Slipway and Engineering Company, Ltd. These three ships are being almost entirely rebuilt, so that cruisers of new design are being superimposed on the fifteen-year-old hulls. With a standard displacement of 9550 tons increased to 11,700 tons at full load, they will have an overall length of 555½ft and a beam of 64ft. Their armament will include four 6in guns in twin turrets and six twin 3in anti-aircraft mountings.

## Modernisation

Turning from ships of new construction programmes to vessels rebuilt under the modernisation programme, the large fleet aircraft carrier "Victorious," which was taken in hand by H.M. Dockyard, Portsmouth, in 1950 for complete reconstruction and modernisation, was nearing completion in the fitting-out basin at the end of last year. Her conversion and rejuvenation constitutes the largest rebuilding project ever undertaken in Great Britain on a warship. She is much heavier, longer, wider and higher than before and is fitted with the angled flight deck, two of the new steam catapults, a deck edge lift in addition to central lifts, the new mirror sight deck landing aids, the latest arrester gear, and improved hangars. When her transformation is complete she will be virtually a new warship, and an aircraft carrier of a much more formidable attack type. When she emerges from rebuilding she will have an estimated displacement of 30,000 tons standard and 40,000 tons full load, an overall length of 786½ft and an extreme beam of 140ft. She will be armed with twelve 3in anti-aircraft guns in twin mountings similar to the U.S. and Canadian pattern, and eighteen 40mm Bofors anti-aircraft guns in three six-barrelled mountings.

H.M.S. "Girdle Ness," the Royal Navy's first guided weapons trials ship was commissioned for service on July 24, 1956. Formerly a landing craft maintenance ship, she was taken in hand in H.M. Dockyard in October, 1953, and completely stripped and reconstructed for her new role. She was originally built in Canada with the hull of a standard merchant ship in 1944, her displacement being 8580 tons standard and 10,200 tons full load, with an overall length of 441ft, a beam of 57ft and a draught of 20ft. Her machinery comprises triple-expansion engines of 2500 i.h.p., turning one shaft and equal to a maximum speed of 10 knots. The guided weapon equipment consists of radar displays and communications apparatus to enable a target to be selected and to control the missiles in flight, magazines and handling gear for stowing and transporting the missiles, which are loaded on to the launcher through hatches. The normal naval complement of the ship is thirty officers and 370 ratings, but she has accommodation for 80 officers and 536 men. The additional accommodation is for the Royal Naval Scientific Service staff and for representatives of the Admiralty, the Ministry of Supply and the firms who manufactured the various equipment.

## Australia

Of the three fleet escort ships of the super-destroyer type being built in the Commonwealth, the "Vampire" was under construction at H.M.A. Naval Dockyard, Williamstown, and the "Vendetta" and "Voyager" were being completed at Cockatoo Island Dockyard, Sydney. The largest vessels of the destroyer type ever built in Australia, they will be basically similar to the "Daring" class built in Great Britain for the Royal Navy, but the design has been modified to suit Australian conditions. With a displacement of 2610 tons standard and 3700 tons full load, they have a length of 390ft overall, a beam of 43ft and a maximum draught of 17ft. They are armed with six 4·5in guns in three twin turrets, two forward and one aft; six 40mm Bofors anti-aircraft guns, ten 21in torpedo tubes in two quintuple mountings; and a squid type anti-submarine triple-barrelled depth charge mortar. Two boilers and two sets of Parsons geared turbines of 54,000 s.h.p., turning two screws, will give them a designed speed of 34·75 knots. A projected fourth ship of the class was cancelled.

Four new fast anti-submarine frigates are also being built in Australian yards, two at Cockatoo Island, Sydney, and two at Williamstown Naval Dockyard.

H.M.A.S. "Quiberon," the last of four destroyers to be converted into fast anti-submarine frigates, was completed at Garden Island, Sydney, at the end of 1956. She and her sister ships, "Quadrant," "Queenborough" and "Quickmatch," are basically similar in arrangement to the first-rate frigates fully converted from destroyers in the Royal Navy.

## Canada

H.M.C.S. "Bonaventure," a new light fleet aircraft carrier, carried out her first sea trials towards the end of the year from the Belfast yard of Harland and Wolff, Ltd., where she was laid down on November 27, 1943, and launched as H.M.S. "Powerful" on February 27, 1945. Her construction was suspended in May, 1946, and she was laid up until it was announced on July 25, 1952, that she had been purchased by Canada for completion by her original builders. She was renamed and her design was recast before constructional work was resumed. She now differs very considerably from the British and Australian carriers of the type of which she was originally a sister ship. She has a heavier displacement of 16,000 tons standard and 20,000 tons full load and an increased overall length of 704ft. Her armament comprises eight 3in guns of the new Canadian pattern in twin mountings (the first time that guns of such calibre have been mounted in a light fleet aircraft carrier) and eight 40mm Bofors anti-aircraft guns. Her main propelling machinery comprises four Admiralty three-drum boilers and a two-shaft arrangement of Parsons single reduction geared turbines working at 350 lb per square inch and developing 42,000 s.h.p., equal to a designed speed of 24·5 knots. She has accommodation for 1370 officers and men.

H.M.C.S. "Assiniboine," the first destroyer escort to be constructed in Canada (illustrated last week, page 30) in every detail, was commissioned for service on August 16, 1956. This ship was laid down on May 19, 1952, and launched on February 12, 1954, by Marine Industries, Ltd., Sorel, Quebec. The "Assiniboine," although the first to be entirely Canadian built, is the second ship of her class. The first was H.M.C.S. "St. Laurent," laid down on November 22, 1950, launched on November 30, 1951, and completed on October 29, 1955. This ship differs from other ships of her class in that her prototype propelling machinery was built in the United Kingdom by Yarrow and Co., Ltd., Scotstoun, Glasgow, while Canadian industry was tooling up: she was wholly designed in Canada, however, and built at the Montreal shipyard of Canadian Vickers, Ltd. The third ship of the class, H.M.C.S. "Ottowa," has just been completed, and Eleven other anti-submarine frigates of this class are under construction. With a displacement of 2000 tons standard and 2600 tons full load, all the vessels of the class have an overall length of 366ft, a beam of 42ft and a draught of 13ft 2in. Anti-submarine weapons are the vessels' principal armament. They include two "Limbo" mortars. The ships are also equipped with homing torpedoes, which can alter course and pursue an enemy target taking evasive action on or below the surface of the sea. The other weapons include four 3in, 50-calibre, anti-aircraft guns, disposed in two twin mountings, one before the bridge and one just abaft the diminutive mainmast. The ships have, in addition, two 40mm anti-aircraft Bofors guns for close-range fire, mounted singly amidships on the low after-superstructure, and a rocket flare projector that can illuminate the sea over a wide area during night action. The motive power is provided by two main and two cruising turbines, geared down to twin shafts and aggregating some 20,000 s.h.p., equal to a speed officially given as "over 25 knots." Except experimentally, the "St. Laurent" was the first ship in the British Commonwealth or the United States in which hardened and ground gearing was used.

H.M.C.S. "Blue Throat" (Fig. 4), a new minelayer and looplayer, also entered service during the year. Built by George T. Davie and Sons, Ltd., Lauzon, P.Q., she has a

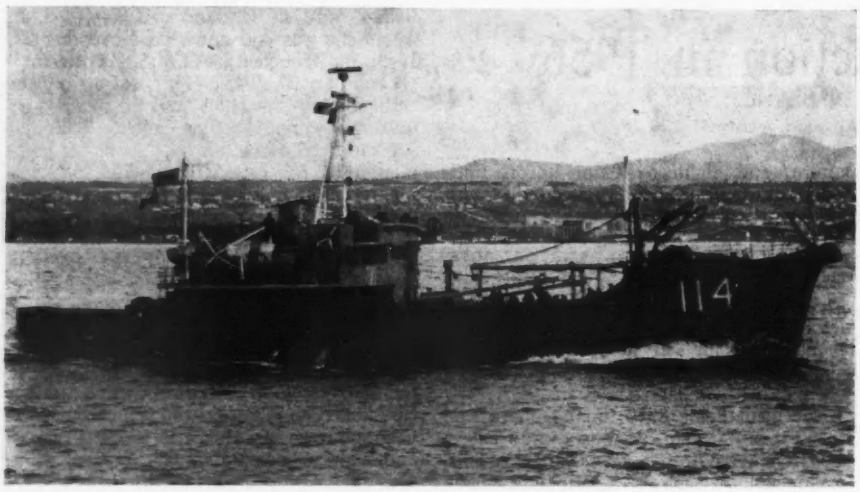


Fig. 4—H.M.C.S. "Blue Throat," new minelayer and looplayer

displacement of 785 tons standard and 870 tons full load, with an overall length of 157ft, a beam of 33ft and a draught of 10ft. Diesels of 1200 b.h.p., turning two shafts, give her a speed of 13 knots.

Other new construction in Canada included six coastal minesweepers of the "Gaspe" class, with a displacement of 412 tons and a speed of 16 knots, and four seaward defence patrol craft of 66 tons with a speed of 14 knots, the first of which is the "Loon," which entered service early in the year.

### United States

The U.S.S. "Saratoga" (Fig. 5), the largest aircraft carrier in the world, was completed and commissioned on April 14, 1956. Built by the New York Naval Shipyard, Brooklyn, she was laid down on December 16, 1952, and floated as recently as October 8, 1955, only six months before being taken over by the United States Navy. With a standard displacement of 60,000 tons and a full load displacement of 76,000 tons, she has a length of 990ft between perpendiculars and 1045ft 10½in overall, a waterline beam of 129½ft, an extreme width of 252ft, and a maximum draught of 37ft. Her main propelling machinery comprises four sets of cross-compound turbines and four double reduction gears manufactured by the General Electric Company turning four shafts and, developing an aggregate of 260,000 s.h.p., equal to a speed of 35 knots, the engines being fed by eight boilers built by New York Naval Shipyard. The turbines and reduction gears are reported to be the lightest ever constructed, yet have the highest horsepower rating of any engines ever installed aboard an American vessel. The new ship has a main armament of eight 5in, 54-calibre dual-purpose guns mounted on sponsons and disposed in single turrets, two on each side forward and two on each side aft. She was designed to carry and operate 90 to 100 aircraft, according to size and type, and to accommodate 3826 personnel (466 officers and 3360 men). The "Saratoga," officially classed as an attack aircraft carrier and designated "CVA 60," is the world's largest vessel and the longest combatant ship, being nearly 7ft longer than the first carrier of the class, the "Forrestal," which was completed on October 1, 1955. She has the standard fixed island superstructure on the starboard side amidships embodying the funnel and all bridges and controls, and surmounted by two "Christmas tree" radar masts stepped somewhat close together and which, in spite of their complexity of yards and aerials at the top, are hinged at the bottom to pass under Brooklyn Bridge. Several British inventions are incorporated in her construction, including a fully angled deck, which gives her a two-runway system, and the new steam catapults, of which she has four, capable of handling the heaviest aircraft. She has three separate launching areas for aircraft, and four deck-edge elevators or outboard lifts which bring up the bombers and fighters from the hangars amidships and on each beam, three to starboard and one to port, instead of on the centre line forward and aft as was the traditional practice in earlier carriers. By the reduction of openings in the hangar sides the flight deck, built of steel, is a strength deck, contrary to former construction methods. The bow is enclosed up to the flight deck to give "hurricane protection" and better seaworthiness in all types of weather, and this new American feature falls into line with British aircraft carrier architecture. On the starboard side of her flight deck the "Saratoga" has a very large sponson jutting out over the sea, even beyond the control island superstructure, and this counterbalances the projection of the angled deck on the port side and serves as an additional parking area for aircraft.

The advance design and procurement of an atomic-powered aircraft carrier was requested in the 1957 fiscal appropriations. She is scheduled to be laid down in 1957 and completed in 1960. According to details released so far she will have a displacement of 85,000 tons with a length of 1000ft, her machinery will include eight atomic furnaces, she will have a small island and a small funnel, and she will carry guided missiles.

On October 16, 1956, it was announced by the U.S. Navy that a contract for the construction of a nuclear-powered guided missile cruiser had been awarded to Beth-

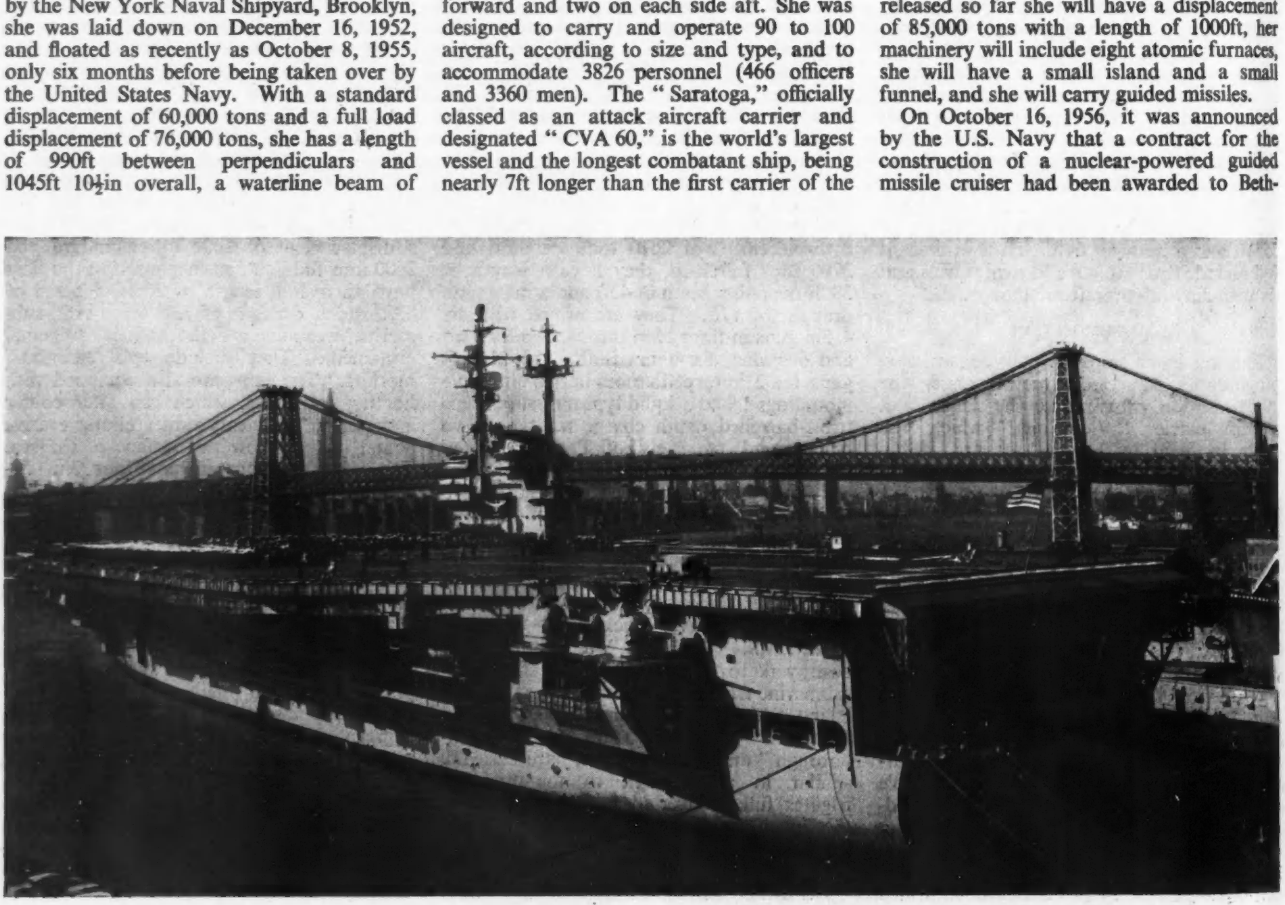


Fig. 5—U.S.S. "Saratoga," completed April 14, 1956. New attack aircraft carrier; largest warship in the world

Fig. 6—U.S.S. "John Paul Jones," completed April 5, 1956. New destroyer

lehem Steel Company, Quincy, Mass. This ship was first projected as a nuclear-powered guided missile light cruiser with a displacement of 9000 tons and designated "CLGN." But subsequent engineering studies indicated that a ship of more like 11,000 tons displacement would be required to mount the missiles the Navy desired. Later investigations proved that an even bigger vessel was necessary to meet the naval requirements. Accordingly, the cruiser, now designated "CG(N)," will have a displacement of approximately 14,000 tons with a length of about 700ft.

Eleven guided missile frigates are under construction. With a light displacement of 3900 tons and a full-load displacement of over 5000 tons they will have an overall length of 512ft and a beam of 50ft. These ships constitute a category without parallel in other navies, being as big as light cruisers although designed more on destroyer leader lines with light scantlings. They will be armed with 5in gun batteries forward and equipped with "Terrier" guided missile installations aft, and will be used primarily for the anti-aircraft defence of high-speed task forces, screening other ships by intercepting enemy aircraft at ranges unsuitable for conventional weapons. Eight new guided missile destroyers "DDG 952" to "DDG 959," are also being built. They will have a standard displacement of 3000 tons, increased to 4000 tons at full load and in addition to two 5in guns will carry guided missile launchers for "Tartar" weapons, which are smaller than the "Terrier" but have greater range.

Several of the big class of eighteen new super-destroyers were delivered or took the water during the year. The prototype and name ship of the class, the "Forrest Sherman," entered operational service early in the year, closely followed by the "John Paul Jones" (Fig. 6), commissioned on April 5, 1956, and the "Barry," completed in October. They were built by the Bath Irons Works Corporation, Maine. This class is larger than all previous destroyers. The entire structure above the main deck, including gun foundations, is of aluminium to obtain the maximum stability while maintaining minimum displacement. With a displacement of 2850 tons standard and 3850 tons full load the length is 418½ft, the beam 45ft and the draught 19½ft. The armament comprises three 5in dual-purpose guns in single turrets, one forward and two aft, four 3in anti-aircraft guns in twin mountings, one before the bridge and one abaft the after control, two "Hedgehog" anti-submarine weapons, four 21in homing torpedoes, and depth charge "Mousetraps." The propelling machinery comprises four boilers and a two-shaft arrangement of geared turbines developing 100,000 s.h.p., equal to a speed of over 35 knots.

The second atomic-powered submarine, the U.S.S. "Sea Wolf," (Fig. 7), laid down on September 15, 1953, and launched on July 21, 1955, was completed in October and was still on trials at the end of 1956. Built by the Electric Boat Division of the General Dynamics Corporation, Groton, Conn., she has engines of a different type, manufactured by the General Electric Company. While the "Nautilus," the first nuclear-powered submarine, has a thermal reactor and water coolant, the "Sea Wolf" has an intermediate reactor and a liquid metal coolant, and she has differing dimensions. With a light displacement of 3260 tons she has an overall length of 320ft and a beam of 30ft. Geared turbines of some 7500 s.h.p. give her a submerged speed higher than the "over 20 knots" officially attained in the "Nautilus."

The reconstruction of the heavy cruiser "Canberra" into a guided missile ship was completed by the New York Shipbuilding Corporation on June 15, 1956. The ship's superstructure has been entirely remodelled to accommodate the new weapons, and she has undergone drastic changes in layout and appearance. The after 8in triple-gun turret and the aftermost 5in twin mounting have been suppressed in the conversion, and two twin guided missile launchers, each capable of firing two "Terrier" supersonic weapons simultaneously, have been mounted in their place. In addition, the "Canberra" carries six 8in guns in two triple turrets forward, ten 5in guns in five twin mountings, two on each beam abreast the forward and after superstructure, and one before the bridge, and twelve of the latest 3in anti-aircraft guns in six twin mounts abreast the masts and after control. But radar apparatus and electronics equipment designed for a maximum of automatic operation, for detecting targets and for guiding the missiles, represent the more radical change in the ship. Another interesting coversion was that of the U.S.S. "Gyatt," into the first guided missile destroyer at Boston Naval Shipyard. She was recommissioned into naval service after her reconstruction on December 3, 1956. In addition to her twin "Terrier" guided missile launchers, she retains some of her 5in and 3in guns for surface action, shore bombardment and close-range anti-aircraft support, and has modern anti-submarine ordnance and detection devices. She is also the first warship in the U.S. Navy to be fitted with the familiar British Denny-Brown stabilisers.

*(To be concluded)*

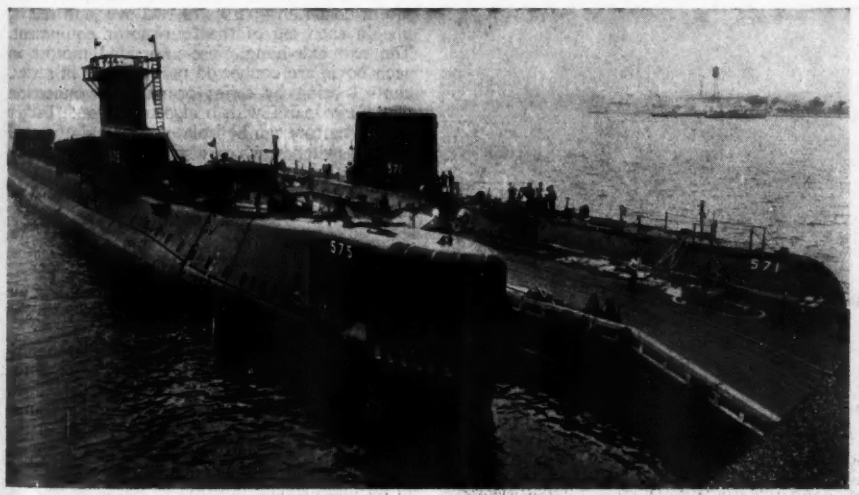



Fig. 7—U.S.S. "Sea Wolf," the new atomic-powered submarine completed at the end of 1956. The "Nautilus" is in the background

## British Standards Institution

*All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.*

### ALUMINIUM CONDUCTORS IN INSULATED CABLES

No. 2791 : 1956. Price 3s.—This new British Standard results from the increasing use of aluminium conductors in insulated electric cables. It provides a standard range of aluminium conductors suitable for use as alternatives to the copper conductors specified in B.S. 7, B.S. 480 and other British Standards for electric cables. The conductor sizes and strand formations given in this standard are closely related to the existing copper sizes and have been chosen to meet the major needs of users. In most cases the resistance of the nearest equivalent copper conductor is within 10 per cent of that of the corresponding aluminium conductor.

### SOLID ROLLED STEEL RAILWAY WHEELS AND DISC WHEEL CENTRES

No. 468 : 1956. Price 3s. This revised standard is part of the general revision of British Standards for railway materials. In this revision the previous practice of allotting individual references to the sections applying to individual materials has been dispensed with, since it was considered that the materials could be adequately identified by the description of the product and the number of this standard. The requirements previously covered by Specification No. 468B, "Solid Rolled Steel Wheels for Wagons (Without Analysis)," have been deleted.

Each specification includes requirements for the quality of the material and for marking and identification, tensile and falling weight tests, and test procedure in general. The specification for disc wheel centres permits the deflection test as an alternative to the falling weight test. The form of the tensile test piece is given in an appendix.

# Electrification of Southend (Victoria) Line

*On December 31 last electric traction was introduced on the line between Shenfield and Southend-on-Sea and through electric train services between Liverpool Street and Southend came into operation. New all-steel, four-coach, multiple-unit train sets are operating on the line which is electrified on the 1500V d.c. overhead system. Provision has been made for conversion at a later date to 25kV, 50 c/s operation of the line.*

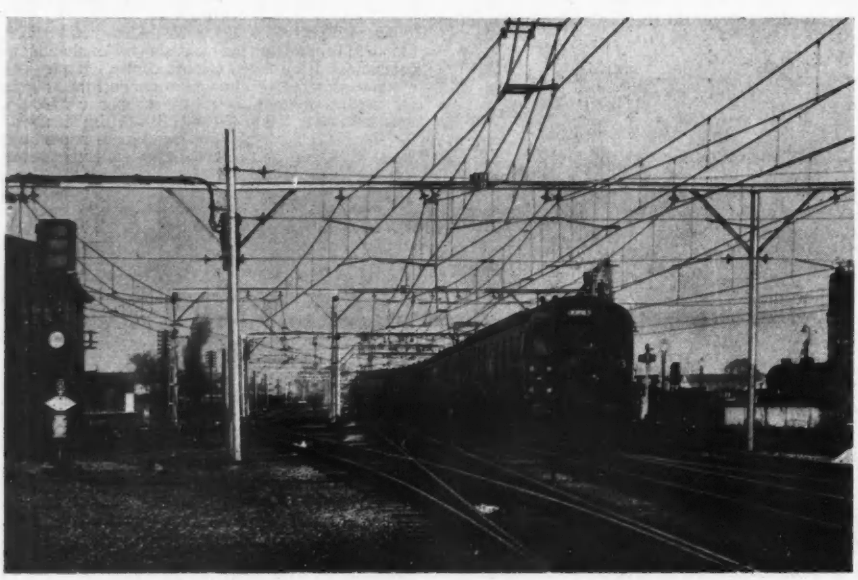
THE final stage in the Eastern Region of British Railways electrification scheme for the Shenfield–Southend-on-Sea (Victoria)–Chelmsford lines was completed on December 31 last, when through electric train services between Liverpool Street and Southend came into operation. This scheme has added over 30 miles of electrified route to the Eastern Region and forms an extension of the Liverpool Street–Shenfield system, which was completed in 1949. The new services now provide, on Mondays to Fridays inclusive, a total of 119 trains daily, compared with sixty-four steam trains as before, the morning and evening peak trains providing seating accommodation for over 18,000 passengers, as compared with the previous 11,700. The electric train service is now some 15 to 20 per cent faster, on average, than was the steam train service.

A considerable amount of civil engineering work was required in preparing the route for this electrification and to provide the necessary clearances for the installation of the overhead line equipment a large number of overbridges had to be raised, nine bridges were rebuilt and two were widened. To bring the permanent way to the required standard for electric traction a number of sections had to be blanketed, new and improved drainage installed and extensive earthworks undertaken.

The whole of this electrification operates on the 1500V d.c. overhead system, and provision has been made for its conversion at some later date to the proposed standard 25kV, 50 c/s for future electrification on British Railways. New substations have been built at Ramsden Bellhouse, Rayleigh and Prittlewell, and track sectioning cabins between the substations at Billericay, Fenton and St. Mary's. These substations and cabins are operated from the control centre at Chadwell Heath. Current is supplied by the Eastern Electricity Board at 33kV, three-phase, 50 c/s to the substations, where it is rectified and fed at 1500V d.c. to the overhead wires. All of the substation equipment was supplied by the British Thomson-Houston Company, Ltd. It includes five 2000kW, 1500V, pumpless steel tank rectifier equipments in substations at Hylands, Ramsden Bellhouse, Rayleigh and Prittlewell. Each rectifier equipment has been designed for twelve-phase operation and comprises two rectifiers mounted on truck underbases and housed in separate cubicles.

The substation a.c. switchgear comprises 33kV, 500MVA and 750MVA single busbar equipment, and at Prittlewell non-automatic circuit breakers are provided for bus-sectioning and incoming isolation. The switchboards are provided with 30MVA, 33,000/650/415/240V plug-in auxiliary transformers to supply 10kVA, three-phase substation auxiliary and 20kVA single-phase signal circuits. For the signalling equipments at three of the substations 650V supplies are taken through a regulating transformer mounted on the pedestal of the auxiliary transformer. These regulating transformers are designed to maintain the signal supply at 650V within ±1 per cent, and the auxiliary transformers are duplicated with suitable changeover facilities. Truck-mounted 1500V d.c. high-speed circuit breakers in the substations are operated by supervisory control from the station at Chadwell Heath. The control desk and equipment at this supervisory control station have been modified to provide improved facilities and to provide for the new extensions. The overhead line equipment which was installed by British Insulated Callenders Construction Company, Ltd., is generally similar to that on the Liverpool Street–Shenfield line.

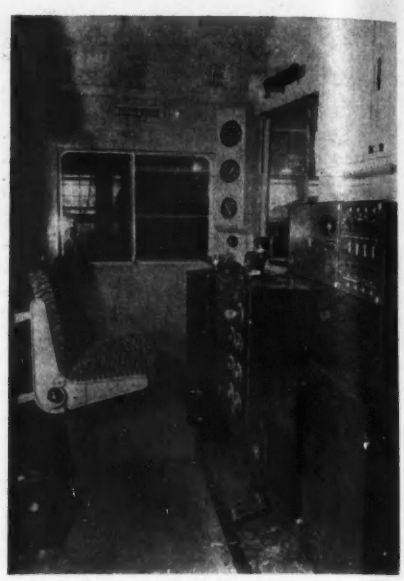
It should be mentioned that d.c.-operated colour light signalling was installed on this line in 1938, but the use of 1500V d.c. traction current has necessitated the conversion of signalling to a.c. operation to avoid interference. The existing signals have been retained, but all the controlling equipment has been replaced by a.c. equipment and the track circuits have been converted for a.c. operation. In this connection the Siemens and General Electric Railway Signal Company, Ltd., has supplied and installed 169 a.c. track circuits, of which 111 are double-rail with impedance bonds; also the associated power cable for 650V a.c. and four telecommunication cables—one eight-pair and three single-pair. The existing searchlight signals have been adapted for a.c. control through transformer-rectifier units, and similar arrangements have been made for d.c. lever locks at ground frames.



**Eight-car multiple-unit electric train leaving Southend-on-Sea (Victoria) Station**

### Train Sets

To operate the new services thirty-two four-coach, multiple-unit train sets have been built at the Eastleigh works of British Railways and fitted with electrical equipment supplied by the General Electric Company, Ltd. Each four-coach train set consists of a driving trailer coach, a motor coach, a trailer coach and a second driving trailer coach. A normal electric train such as that to be seen in one of our illustrations, consists of two four-coach sets coupled together.



**Driver's compartment in a driving trailer of new multiple-unit train**

Each four-coach set provides accommodation for nineteen first-class passengers, in compartments with side corridors, and 344 second-class passengers. For the second-class passengers 140 seats are provided in open saloons and 204 in compartments; four toilet compartments are provided in each train set. The combination of compartment and open type stock, with two classes, has been adopted for these trains because of the nature of the traffic on the Southend line, which consists both of regular business travellers and holiday visitors with luggage. The equipment has been designed to operate on a sixty-minute limited stop service.

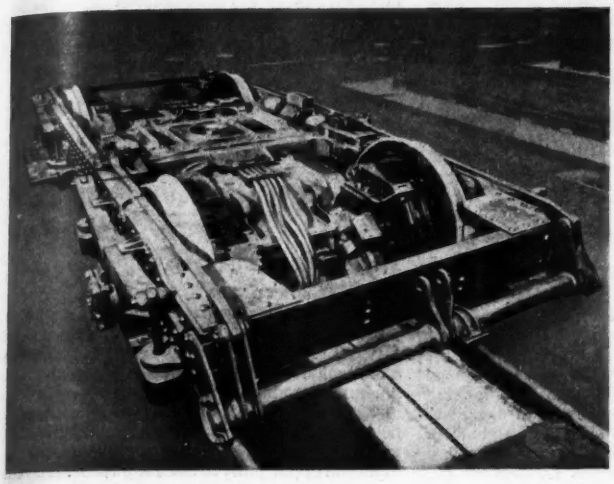
Current is collected by a pantograph on the motor coach and passes to two overload relays, one in each leg of the four-motor equipment. The two axle-hung, nose-suspended motors in each bogie are connected permanently in series, control being by series or parallel connection of the two pairs, with bridge transition. Either pair of motors can be isolated by hand-operated cut-out switches, which also make the necessary modifications in the control circuit. The continuous and one-hour ratings of a unit are as follows :—

| | Full field, h.p. | Weak field, h.p. |
|---|---|---|
| Continuous rating ... ... ... ... | 632 ... ... | 696 |
| One-hour rating ... ... ... ... | 800 ... ... | 880 |

The self-ventilated motors take in cooling air direct through protected inlets on top of the frames.

The electro-pneumatic contactor control equipment, with the relays, reversers and motor cut-out switches, is accommodated in three cases mounted in the motor coach underframe, and is operated from master controllers in the driving trailers. No driving compartment is situated in the motor coach, which is arranged in an intermediate position in the train set. A shunting notch and three running notches are provided, the former having a rating to permit shunting movements and other slow running

with all resistance in circuit. Movement of the controller handle to the series, parallel or weak field positions initiates automatic acceleration to the selected notch. One section of resistance is in circuit only on the shunting notch, its subsequent elimination assisting in the balancing of the circuit for the bridge transition. There are nine resistance notches in the automatic progression to full series and four to full parallel. During acceleration in parallel the corresponding sections of resistance in each motor branch are



Motor bogie of the new multiple-unit stock fitted with two axle-hung motors

short-circuited together. There is one weak field running notch, but this is reached through an intermediate step in which a portion of the motor fields is diverted by resistances. In the final step the fields are weakened by tapping. To reduce the demand when taking the weak field steps, and also to keep the current peaks within reasonable limits, a separate current limit relay having a lower drop value than the main relay is used.

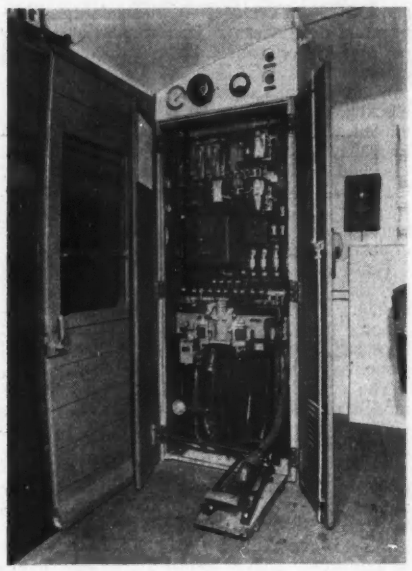
Two rates of acceleration can be selected by alternative "forward" positions of the reverser handle. The normal rate corresponds to 1·1 m.p.h.p.s., while the lower rate, intended for use in greasy rail conditions, is 0·85 m.p.h.p.s. When the higher rate is selected, the drop values of the main and weak field current limit relays are modified by means of shunt coils.

Operation of an overload relay causes a protective resistance to be brought into circuit before the current is broken finally by a line switch. When an overload relay trips, auxiliary contacts energise an indicating relay and cause a lamp to light in the van compartment of the motor coach affected. This relay latches in, so that the lamp is not extinguished when the overload relay is reset by push button from the driving cab, and remains alight to identify the faulty unit (provided the train line key switch is in position) until the indicating relay has been reset by hand. In the event of a supply failure a no-current relay opens all line switches and contactors. The equipment will renotch automatically to the condition dictated by the position of the master controller handle when the supply is restored.

In the control contactors the butt contact interlocks, set under "Perspex" protective covers, and the electro-pneumatic valves are mounted at the front so that both are accessible when the front covers of the equipment cases are removed. The trains are equipped with a new design of control receptacles and jumpers using butt contacts, in order to simplify coupling up of trains and to ensure good contact at all points with a positive locking of the jumper in position.

The auxiliary supply to a motor generator set, a Westinghouse compressor and coach heater lines is taken from the pantograph through a 60A main auxiliary fuse, which provides back-up protection should the compressor contactor motor generator fuse, or heating fuse, fail to clear. Fault currents in the auxiliary machines are limited by a protective resistance, and a 20-ohm resistance on the negative side of the compressor motor limits its starting current. This machine and the motor generator set are started direct to line, through all-electric contactors. A resistance having part of its value on the positive side of the motor generator set motor and part on the negative side provides stability for through currents, as at starting; the positive section limits the fault current in case of a flash-over to earth in the machine. The input to the motor at 1350V is 10·1A at 1625 r.p.m., and its low-tension generator, rated at 9·5kW (52V, 183A continuous) provides current, controlled by a carbon pile voltage regulator, for the control circuits, battery charging, train lighting and water heating. A feed is taken through a main water heater fuse to a bus line supplying four 1½kW, 1-gallon water heaters in a train unit. Each motor generator set supplies the lighting for its own four-coach set. A lighting main fuse provides overall protection, but sub-circuit fuses protect individual coach lighting groups. Train lighting is controlled by a contactor which incorporates set and trip gear. A 55Ah alkaline battery carried on the underframe of the motor coach can supply the control and essential marker lights of a twelve-car train for about two hours.

A cubicle which contains the majority of the l.t. control equipment is housed in a van compartment in the motor coach. A foot pump for raising the pantograph is also housed in the cubicle and it can be hinged down into the operating position, as shown in our illustration, after the door has been opened. When the pantograph is raised by the pump, the auxiliary relay which completes the circuit for closing the compressor and motor generator contactors is set by hand, so that the machines start as soon as the pantograph touches the overhead line.



L.T. equipment cubicle in motor coach van compartment, showing pantograph foot pump in operating position

When air is available, however, the pantograph is raised by pressing a push button in the driving trailer, this action closing the auxiliary relay electrically. On operating the "panto down" push button in the driving trailer, the auxiliary relay is tripped; its contacts de-energise the heater, motor generator and compressor contactors so that the possibility of breaking current at the pantograph pan is precluded. If for any reason it is necessary to shut down the motor generator set from the van position, the isolator in the equipment cubicle can be opened to de-energise the motor generator contactor.

The 1500V supply to the train heating lines is taken from the negative side of the main auxiliary fuse through a contactor and a fuse for each line. The carriage heaters, fitted under the seats, are rated at 500W and are connected five in series.

# Transonic Tunnel Testing Technique

*The Royal Aeronautical Society, on December 20, 1956, held an all-day meeting devoted to transonic wind tunnel testing techniques. We record below some of the issues of the discussion.*

*Measurement of Tunnel Speed.*—An interesting point was brought out in the discussion concerning the measurement of "free-stream" speed. Although all tunnel workers seemed agreed that plenum chamber pressure gave a good average figure, some doubt was expressed in certain specific cases. There is no theoretical backing for the idea that free-stream speed is equal to the integral of speeds along the tunnel walls near the test specimen. Difficulty also arises if speed is measured at one specific point on the tunnel wall.

Due to detachment of model bow wave, the speed measurement point should be well ahead of the model at low supersonic speeds, and be moved back progressively as the Mach number is increased.

Examples were given of models at high incidence where the flow upstream had a different Mach number from that downstream. This was probably associated with blockage due to finite wake thickness, and was considered to invalidate the tests.

*Economy of Power.*—One point which became apparent as the discussion proceeded was the much greater efficiency of the tunnels employing auxiliary suction plant. These tunnels took only 400 h.p. to 500 h.p. per square foot per atmosphere, as against a figure of over 2000 h.p. per square foot for the tunnels employing diffuser suction. This fivefold efficiency is achieved at extra capital cost of plant for auxiliary suction.

The diffuser suction type of tunnel necessitates a greater pressure ratio, accounting for the extra power consumed, but at the same time the prime mover may be used for ordinary supersonic tunnel operation at these higher pressure ratios. It was felt that many firms would prefer a single tunnel for transonic work, which could also be used for Mach numbers up to 2·0 or more, rather than locking up additional capital in two tunnels, one of which had a much better economy of power.

It was suggested by one speaker that the pressure ratio to drive $M=1·2$ slotted, equalled $M=1·55$ solid, and by another that $M=1·3$ slotted equalled $M=1·6$ solid, using diffuser suction in both slotted cases.

It was agreed that slotted sections took more power than the perforated, but this was offset by the greater porosity required in the perforated case. It was established that electrical drive was cheaper in power cost than kerosene, by a factor variously estimated at between twice and four times.

*Working Section Design.*—There was agreement on the necessity to connect upper and lower plenum chambers with a pressure equalising duct if correct values of $dC_L/da$ were to be measured.

Some working section velocity distributions

showed clear evidence of irregularities propagating downstream. One cure was to apply perforated sheet behind the slots in the method employed at R.A.E., Bedford.

Many statistics concerning permissible tunnel blockages for various tunnels and models were quoted. High blockage was thought to give a buoyancy effect on drag. One speaker said that $C_{Do}$ had been reduced by one-third in going from 0·24 per cent to 1·6 per cent blockage. In general most operators were trying to keep below ½ per cent blockage, but tolerating up to double this amount as the necessity arose.

Half models were not favoured as a method of "getting away" with larger models in a given tunnel.

Some methods of deflecting or nullifying the boundary layer on the wall defining the neutral plane were described.

The permissible blockage was less for bluff models than for more pointed models, leading one to suppose it may be the drag which is important.

Shock reflection on the rear of the model from the bow wave was considered to be detrimental, even in the case of perforated tunnels. It appears that this region (say, $M$=1·05 to $M$=1·15) will have to be avoided in future serious work, even if results are quoted in this region for design purposes. This is an important reason for achieving $M$=1·3 to $M$=1·4 as a top transonic speed, and not being content with $M$=1·2 or less.

Shock reflection from a standard hemispherical headed A.S.I. was shown to have a marked effect when it struck the static pressure slots.

*Contraction and Diffuser Design.*—In the discussion two speakers suggested that disturbances could arise from too little attention to the design of the contraction. It was recognised that a difficulty arose if throats of different sizes for different Mach numbers had to be accommodated.

Diffuser design called for much comment, but no very definite conclusion was reached, except that the "Boeing" type of flap was commended by those who had used it.

*Tunnel Temperature.*—The difficulties associated with model design for gas turbine-driven tunnels were discussed. Operating temperatures of 176 deg. Fah. for subsonic speeds, 212 deg. Fah. for transonic operation and 320 deg. Fah. for $M$=1·6 were agreed as reasonable and likely. At these temperatures, differential thermal expansion has to be guarded against, and many useful materials such as soft solder and Araldite have to be discarded.

The electrically-driven tunnel with adequate cooling to reduce model temperature to atmospheric, or close to that figure, has a great advantage in this respect. This is offset by the necessity to install a chemical dryer instead of preventing condensation of moisture by simple heating as in the case of the gas turbine tunnel.

## Generating Plant Installed in C.E.A. Power Stations in 1956

THE Central Electricity Authority states that new generating plant installed in C.E.A. power stations during the year ended December 31, 1956, yielded an additional output capacity of 1797MW. In addition, new plant with an output capacity of 140MW was commissioned in power stations owned by the South of Scotland Electricity Board, making a total of 1937MW of generating capacity in the area of the former British Electricity Authority, and surpassing last year's total of 1721MW by 12½ per cent.

The additional C.E.A. plant, comprising thirty-eight turbo-generators, with an aggregate installed capacity of 1920MW, and fifty boilers having an aggregate evaporative capacity of 18,715,000 lb per hour (as detailed in the accompanying table), was installed in thirty-three power stations. Four of them are new stations, in which plant was installed for the first time.

To remove certain misunderstandings regarding the length of time required for the construction of conventional steam power stations, the Authority points out that the initial construction time following Ministerial consent is usually about 3½ years. For example, in the case of the twin Stella power stations on the Tyne the first unit was generating power 3½ years after consent and eight more sets, making 540MW capacity in all, were installed in the next two years. At Ince power station in Cheshire, the first unit was also generating electricity 3½ years after consent to proceed and the station of 240MW was completed by the installation of three more units within the next twenty-one months. The full development of the Marchwood site on Southampton Water envisages the installation of eight 60MW units planned to be installed in two groups. The installation of the first four sets in this station has now been completed. The first set was commissioned 3½ years from the start of site work and the next three sets were commissioned within the next twelve months, thus increasing the plant available in the area by 240MW. This result was achieved notwithstanding the complexities involved in carrying out the decision that oil should be burned in this station, for which change formal consent was given only nine months before commissioning of the first set.

## High Pressure Air Drying Equipment

AN exhibition of "Lectrodryer" drying equipment for air and other gases at very high pressures recently held at Birmingham by Birlec, Ltd., Tyburn Road, Erdington, Birmingham, included representative designs of the high pressure compressors and other equipment made by a number of other firms. A conference held in conjunction with the exhibition gave manufacturers of high pressure plant and the dryers an opportunity to discuss with Government departments and other users their requirements and problems.

Several of the continuous "Lectrodryer" equipments for very high pressure operation which were exhibited were of the maker's oesign having dual absorbers, consisting of pressure vessels filled with the activated alumina desiccant. In these plants the vessels are connected in turn to the air stream, and whilst one is on drying duty the other vessel is being reactivated by a built-in heater and blower. Valves are operated at the required intervals to change

*Central Electricity Authority Power Station Construction. Plant Commissioned in the Year, 1956*

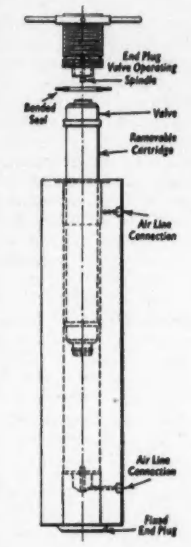
The plants listed below, complete with all associated ancillary equipment, have been commissioned during the twelve months of the year 1956 :—

| Name of power station | C.E.A. divisions | Turbo-generator plant | | Boiler plant | | Main high pressure pipework |
|---|---|---|---|---|---|---|
| | | Installed capacity in MW | Maker | Capacity in k lb per hour | Maker | Maker |
| Steam plant : | | | | | | |
| Acton Lane "B" | London | — | — | 1×240 | Mitchell | Aiton |
| Bold "A" | North Western, Merseyside and North Wales | 1×30 | Metropolitan-Vickers Electrical Company, Ltd. | 1×300 | Yarrow | Aiton |
| Brunswick Wharf | London | 1×60 | Metropolitan-Vickers Electrical Company, Ltd. | 1×320 | John Brown | C. A. Parsons |
| Carmarthen Bay | South Wales | 1×60 | Metropolitan-Vickers Electrical Company, Ltd. | 2×240 | Babcock and Wilcox | Stewarts and Lloyds |
| Carrington | North Western, Merseyside and North Wales | 1×60 | Metropolitan-Vickers Electrical Company, Ltd. | 2×360 | John Brown | Stewarts and Lloyds |
| *Castle Donington | East Midlands | 1×100 | Metropolitan-Vickers Electrical Company, Ltd. | 2×830 | Babcock and Wilcox | Aiton |
| Chadderton "B" | North Western, Merseyside and North Wales | 1×60 | Metropolitan-Vickers Electrical Company, Ltd. | 1×360 | Simon-Carves | Stewarts and Lloyds |
| Connahs Quay | North Western, Merseyside and North Wales | 1×30 | C. A. Parsons | 1×300 | International Combustion | John Thompson |
| Deptford East H.P. | London | — | — | 1×250 | Foster Wheeler | John Thompson |
| Doncaster "B" | Yorkshire | 2×30 | Bruth Electrical Company, Ltd. | — | — | Aiton |
| East Yelland | South Western | 2×30 | C. A. Parsons | 4×180 | John Thompson | C. A. Parsons |
| Goldington | Eastern | 2×30 | British Thomson-Houston | 2×300 | Clarke, Chapman | Stewarts and Lloyds |
| *Hams Hall "C" | Midlands | 2×60 | General Electric Company | 2×550 | Simon-Carves | Stewarts and Lloyds |
| Huddersfield | Yorkshire | — | — | 1×180 | Bennis | C. A. Parsons |
| Huncoat | North Western, Merseyside and North Wales | 1×30 | General Electric Company | 1×305 | Simon-Carves | C. A. Parsons |
| Ince | North Western, Merseyside and North Wales | 1×60 | General Electric Company | 1×550 | International Combustion | Babcock and Wilcox |
| Littlebrook "C" | South Eastern | 1×60 | C. A. Parsons | — | — | C. A. Parsons |
| Marchwood | Southern | 3×60 | English Electric | 3×550 | John Thompson | John Thompson |
| Meaford "B" | Midlands/Headquarters | 1×60 | British Thomson-Houston | 2×515 | Babcock and Wilcox | Babcock and Wilcox |
| Northampton H.P. | East Midlands | 1×30 | Brush Electrical Company, Ltd. | 2×150 | Bennis | Stewarts and Lloyds |
| Nottingham H.P. | East Midlands | — | — | 1×300 | Mitchell | Aiton |
| Ocker Hill "A" | Midlands | 2×30 | Richardsons, Westgarth | 2×180 | Babcock and Wilcox | Aiton |
| Portishead "B" | South Western | 1×60 | Metropolitan-Vickers Electrical Company, Ltd. | 3×300 | Mitchell | Stewarts and Lloyds |
| Skelton Grange "A" | Yorkshire | — | — | 1×550 | International Combustion | Aiton |
| Staythorpe "A" | East Midlands | 1×60 | British Thomson-Houston | 1×240 | Babcock and Wilcox | Babcock and Wilcox |
| Stella North | North Eastern | 2×60 | C. A. Parsons | 2×550 | Clarke, Chapman | C. A. Parsons |
| Stella South | North Eastern | 2×60 | C. A. Parsons | 2×550 | Clarke, Chapman | C. A. Parsons |
| *Tilbury "A" | Eastern | 3×60 | English Electric | 3×540 | John Thompson | John Thompson |
| Uskmouth "A" | South Wales | 1×60 | General Electric Company | — | — | Aiton |
| Wakefield "B" | Yorkshire | 2×60 | English Electric | 2×550 | Foster Wheeler | Aiton |
| Woolwich | London | — | — | 1×180 | John Thompson | C. A. Parsons |
| York | North Eastern/Yorkshire | 1×20 | Brush Electrical Company, Ltd. | 2×100 | Richardsons, Westgarth | John Thompson |
| | Totals | 1920MW | | 18,715 k lb per hour | | |
| Diesel plant : | | | | | | |
| *Machynlleth "B" | North Western, Merseyside and North Wales | 3×1330 | Mirrlees, Bickerton and Day | | | |

* New stations in which plant has been commissioned for the first time in 1956.

over the vessels from drying to reactivating cycles.

A new design of cartridge dryer has been developed by the firm for use where reliability combined with light weight is essential, such as in aircraft. For this form of dryer the desiccant can be supplied in a self-sealing cartridge which is opened on insertion in the dryer body or the reactivator unit. The cartridges can be changed in these dryers without need for disconnecting the inlet and outlet pipes of the system and the construction of a dryer can be seen in the drawing we reproduce. It has a high pressure cylindrical body with connection points for the air line near each end and is permanently sealed at one end by a fixed plug. The cartridge in which the desiccant is sealed has spring-loaded poppet valves at each end. When the cartridge is inserted in the body short spindles projecting from the faces of the fixed plug at one end and the removable plug at the other end register on the valve spindles. When the removable plug is screwed right in the cartridge valves are fully opened to permit the air to flow in one end, through the desiccant and out of the other end of the body. The valves are operated in a similar manner when a cartridge is placed in a reactivator. With this sealing means the desiccant in a cartridge is not subjected to the risk of exposure to moist atmosphere air as it cools down after reactivation. Cartridges of this design are made in two sizes known as the G2·5 and the G5. The table below gives typical capacities for a gas entering saturated at 90 deg. Fah. to an outlet dewpoint of 0·02 m.g./litre at s.t.p.




**Arrangement of high pressure cartridge dryer**

During the course of the exhibition a film "Free Escape" was shown describing submarine escape procedure with a built-in breathing system. For this system a mixture of oxygen and nitrogen at 3000 lb is passed through a compressor which boosts the pressure to 4000 lb per square inch. This mixture is passed through a "Lectrodyer" where the moisture content is removed to give a dewpoint of plus 40 deg. Fah. at pressure. The gas mixture is then stored in three cylinders housed on the outside of the submarine. A reducing system lowers the pressure to a value within 100 lb of the pressure inside the cabin where the breathing mixture is fed to a series of manifold couplings into which the men plug their breathing supply devices. Sealed escape chambers are provided fore and aft in the submarine and each man takes in a sufficient quantity of the oxygen-enriched air to balance pressures and enable him to reach the surface.

| Steady pressure lb/sq. in g. | Flow s.c.f.m. | G2·5 Total per cartridge s.c.f. | G5 Total per cartridge s.c.f. |
|---|---|---|---|
| 6250 | 70 | 8700 | 17,500 |
| 4500 | 60 | 8500 | 17,000 |
| 3000 | 50 | 7500 | 15,000 |

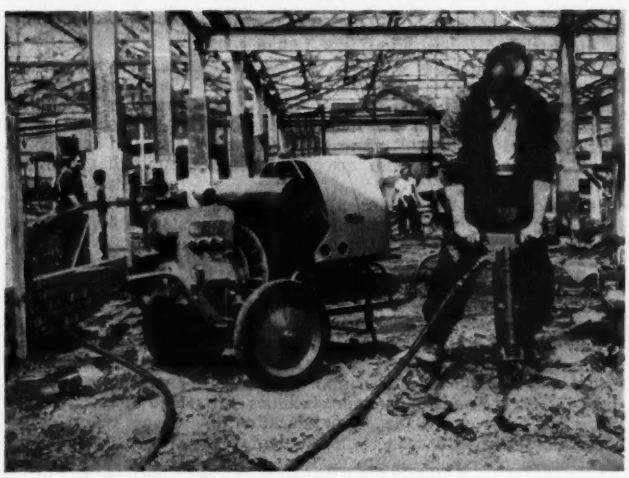
An interesting exhibit in connection with this film was one of four "Lectrodryers" used for drying the air in submarine free-escape breathing equipment plant. This machine is designed for continuously drying 50 s.c.f.m. of compressed gas (40 per cent oxygen—60 per cent nitrogen) saturated at 125 deg. Fah. and flowing at a pressure of 4000 lb per square inch. It gives an outlet dewpoint of ±40 deg. Fah. on an eight-hour changeover reactivation period.

High pressure air compressors and accessories made by following firms were exhibited: Belliss and Morcom, Ltd.; Peter Brotherhood, Ltd.; Dunlop Rubber Company, Ltd.; Hamworthy Engineering Company, Ltd.; Hymatic Engineering Company, Ltd.; Reavell and Co., Ltd.; Rotax, Ltd.; G. and J. Weir, Ltd.; and Williams and James, Ltd.

## Mobile Air Compressor

THE small mobile air compressor to be seen at work in the illustration below is now being made by the Hymatic Engineering Company, Ltd., of Redditch. It has a displacement of 60 cubic feet per minute with a working pressure of 100 lb per square inch, and its relatively light weight of 576 lb makes it readily manœuvrable on site.

The compressor is of the firm's "Hydrovane" oil-sealed construction with cooling by a centrifugal fan and an oil cooler. In this design the air is cooled during compression by the large volume of lubricating oil which seals all internal clearances and maintains a consistent free air delivery of 48 cubic feet per minute at 100 lb per square inch. Built into the machine are the air intake and delivery filters, an oil filter, safety valve, pressure gauge and an automatic unloader pressure control. Two main outlet lever cocks are also provided.



**Mobile air compressor with a free air delivery of 48 cubic feet per minute at 100 lb per square inch**

The compressor is driven by a four-cylinder, air-cooled petrol engine developing 22 b.h.p. at 2200 r.p.m. A centrifugal governor controls engine speed and an additional speed control is operated from the air delivery side of the compressor to regulate engine speed in accordance with air consumption.

The compressor and engine are bolted directly to a mounting flange and are connected through a flexible coupling. They form a single rigid unit, which is carried on a frame of light alloy tubes with detachable carrying handles at each end. The undercarriage consists of two large diameter pneumatic-tyred wheels carried on an axle secured to the frame by quick-release clamps. With the undercarriage removed the weight of the machine is reduced for carrying purposes to 520 lb.

## Problems of Aircraft Production

SPEAKING at the opening luncheon at the Institution of Production Engineers' conference on "New Materials—New Methods," last Tuesday, Mr. R. Maudling, Minister of Supply, suggested that the products of the British aircraft industry should be compared with those of the United States aircraft industry, the only other major producer in the Western world. Proceeding to this comparison, he stated that Britain was clearly behind with supersonic aircraft, such as fighters, because of her failure to take part in research with manned aircraft, and once the U.S. had been given a lead it was not easily recovered. The V-bombers he deemed equal to or better than American products, while he considered that, to sell in the dollar market, a British airliner must be clearly superior. The U.S.S.R., with the advantages of vast resources and a centrally controlled economy, must be expected to offer severe competition. The Minister went on to say that the crux of the British problem was development work, expenditure on which might be equal to expenditure on production. The ability of the engineers concerned must overcome the disadvantages of limited facilities, bad weather, and small markets handicapping our industry. He reiterated that fewer projects must be pursued, particularly among military aircraft. Discussing whether there were too many firms in the industry, Mr. Maudling observed that larger and stronger firms were an improvement, but it was not for any man or body to say what number there should be. The optimum would emerge as a logical consequence of the demands made upon the industry.

Reading the Lord Sempill paper on Tuesday afternoon, Herr Direktor K. Frydag advised in more explicit terms that the diversity of projects in this country be reduced. He traced the story of aircraft production for the Luftwaffe: the Air Ministry dictated the development of one night fighter, two other fighters, and two bombers, with only three different engines. Simultaneously a number of producing firms were established, financed by a special bank established by the State. Planning was sufficiently complete and accurate for production programmes to be met in full. In contrast, in 1942 efforts were made to alter greatly the planned outputs and, in particular, to build more basic types. The loss of output was so severe that the policy of concentrating on few machines was reinstated: it was to that policy that Herr Frydag attributed the increase of fighter production from 2000 a month in early 1944 to 4800 in September, in the teeth of strategic bombing of the factories.

Such an intricate structure as an aircraft industry could not be controlled by an outside agency such as a Ministry: however eminent the members of the Ministry were, they would shortly lose intimate contact with the industry. A board of industrialists should share the responsibility of the Government, and avoid, for instance, parallel developments originating only in the special interest of a firm. Great Britain, he believed, was in an extremely dangerous position: what would she be able to produce if war broke out tomorrow? He suggested that British efforts should be concentrated on civil and military transports, on one long-range and one interceptor fighter, and on a supersonic bomber. Guided missile work should be in co-operation with Europe and U.S.A., and a night bomber should be built under a U.S. licence.

SYMPOSIUM ON CORROSION OF METALS IN BUILDINGS.—The corrosion group and the road and building materials group of the Society of Chemical Industry are arranging jointly a symposium on corrosion of metals in buildings, to be held at the Institution of Civil Engineers, Great George Street, London, S.W.1, on Thursday, March 21, 1957, from 9.30 to 6 p.m. The papers to be presented are as follows: "The Resistance of Non-ferrous Metals to Corrosion in Buildings," by F. E. Jones; "The Corrosion of Ferrous Metals in Buildings," by J. C. Hudson and F. Wormwell; "Corrosion of Metals in Contact with Concrete," by P. E. Halstead; "Aluminium Cladding of Buildings," by E. H. Laithwaite and E. W. Skerrey; "The Performance of Zinc and Zinc Coatings in Buildings," by R. W. Bailey and H. G. Ridge; "The Behaviour of Copper in Buildings," by S. Baker and E. Carr. Further particulars may be obtained from the Society of Chemical Industry, 14, Belgrave Square, London, S.W.1.

# Industrial and Labour Notes

### Economic Report

During the past week, the information division of the Treasury has published, in its *Bulletin for Industry*, various economic statistics relating to 1956. The *Bulletin* says that, since last June, the trade figures, which are the only up-to-date indicators of the balance of payments, have stayed good. For the eleven months, January to November, total exports were 11 per cent higher than in the corresponding period of 1955, and imports were 1 per cent higher, by value. By volume, exports were 6½ per cent higher and imports were the same. As to the terms of trade, import prices, after falling seasonally in the third quarter of last year, rose 4 per cent between August and November, whereas export prices rose only 1 per cent. Consequently, since last August the terms of trade have turned 3 per cent against us. But at the end of the year, the *Bulletin* adds, they were still more favourable than the 1955 average.

In the third quarter of last year, and also in October, the *Bulletin* says, industrial production remained steady and showed no appreciable change. In the first ten months of last year the index was less than 1 per cent higher than a year earlier ; seasonally adjusted it was 2 per cent lower than in the final quarter of 1955. For all industries, over the first ten months of last year, the index of industrial production (1948=100) was 137. About the retail price index, the Treasury comments that between mid-October and mid-November it rose by under half a point, mainly because of increases in some food prices and a seasonal rise in the price of coal.

The *Bulletin* goes on to say that it is hard to assess the effect which the Suez emergency may have on the index of retail prices. The increase in petrol and certain other oil prices will add, on private motoring account, about one-quarter of a point to the index, and through bus fares—if all were raised to the maximum allowed—it would add one-fifth. There is also likely to be some further increase because of temporarily higher costs of distribution. These effects, taken together, may result in an increase of up to three-quarters of a point. Freight rates have also risen. The general prospect, according to the Treasury, is that the index of retail prices is likely to rise slightly more than seasonally in the early part of this year. The main cause, however, is the " purely temporary increase in the petrol and oil duty." It is therefore of the utmost importance, the *Bulletin* urges, that any small rise in the index is not presented as justification for increases in wages and in profit margins, which in themselves would tend permanently to raise the price level.

### Steel Export Policy

Some comments about this country's steel export policy are made by Mr. B. Chetwynd Talbot, chairman and managing director of South Durham Steel and Iron Company, Ltd., in a statement circulated with the annual accounts. Mr. Talbot says he considers it his duty to draw attention to the contradiction in policy which is becoming manifest with regard to the restrictions of steel exports imposed on the industry. His statement recalls remarks made by members of the Government about the absolute necessity not only of maintaining the existing levels of export, but in particular of increasing the proportions to the countries from which the essential currencies are secured in order to safeguard the national economy. Mr. Talbot then suggests it has become apparent, in recent years, that by the restoration of the iron and steel industry to the control of individual investors, the approach to these problems and the methods of execution necessitate careful examination.

The statement goes on to express appreciation of the important part which, during a period of some twenty-two years, the British Iron and Steel Federation has exercised in achieving the present level of efficiency in the industry. Mr. Talbot then puts forward the view that, in the interests of the further development and expansion of the iron and steel industry, a more direct method of approach for discussing its problems with the Government requires to be established than exists to-day. He says that he does not question the correctness of empowering the British Iron and Steel Federation to act as a medium for discussions between the Government and the industry, prior to the passing of the Iron and Steel Act, 1953. But, Mr. Talbot adds, since approximately 75 per cent of ingot production has been restored to private ownership, should the British Iron and Steel Federation be " entitled to continue exercising these powers ? " It is necessary to bear in mind, Mr. Talbot remarks, that the British Iron and Steel Federation has never possessed executive powers with regard to the financial obligations of individual companies nor responsibilities affecting earning powers. The position, Mr. Talbot thinks, now requires revision " to endeavour to secure that more direct forms of contact are established between the Board of Trade, the Iron and Steel Board, and the industry."

### British Institute of Management

A working plan for the complete integration of the British Institute of Management and the Institute of Industrial Administration has been approved by the two councils. The necessary legal documents are being prepared and extraordinary general meetings of the two institutes will shortly be called with the object of bringing complete integration formally into effect on April 1.

The British Institute of Management was founded in 1947 as the central national body for the study and promotion of scientific management. Its chief activities are the co-ordination of the study of management, the provision of an information service for member companies, the holding of conferences and the publication of literature on management subjects and the development of management education in Britain. The Institute of Industrial Administration was founded in 1920 " for the purpose of providing a medium for the interchange and development of ideas and practice pertaining to the better operation of industrial enterprises in the interests of both employer and employed." The two institutes have been working in close association since 1949.

It is proposed that the name of the integrated body shall be the British Institute of Management, but the name of the Institute of Industrial Administration will remain registered to prevent its use by any other body. The main objectives of the integrated Institute are summarised briefly as to co-ordinate activities and thereby avoid duplication and overlapping with other institutes or organisations in the management field ; to collect and disseminate information of management practices, and to provide facilities for research ; to develop management education of every kind, and to exchange information with other cognate bodies nationally and internationally ; and generally to advance the knowledge of good management practice.

### Budget Recommendations

It would appear that the Association of British Chambers of Commerce is " first in the field " this year with recommendations for the Chancellor of the Exchequer's guidance in framing the Budget. The Association's suggestions are set out in a pamphlet which was issued at the beginning of the week.

In this pamphlet, the Association comments that much has been said about the economic difficulties of this country since the war, but it urges that " there is no other salvation than work and thrift in all members of the community." To try to avoid this, the Association adds, " by pushing the work on to others by demanding more pay for less work, and by spending to-day regardless of to-morrow, can only lead to everyone being poorer." The pamphlet goes on to emphasise that the road to higher standards of life lies in increased technical knowledge and in the increased use of machinery to augment human ability. This, it is pointed out, calls for savings now, for capital expenditure is limited by the ability of savings to pay for it.

In its " proposals," the Association urges that the " Government should save, should encourage people to work and save, and it should avoid frustrating work, expropriating savings or permitting them to become worthless through inflation." It is therefore suggested that the forthcoming Budget should restore the investment allowance to assist modernisation of equipment ; encourage business in foreign markets by introducing the Overseas Trade Corporation, as recommended by the Royal Commission ; reduce production costs by removing purchase tax from goods used in business, and by reducing the tax on petrol and oils as soon as possible ; and encourage work by raising the earned income relief and by making personal and earned income allowances effective for surtax. Among the recommendations for assisting businesses, the Association includes the following : allowing trading concerns to value their stock in trade on a basis appropriate to their trade ; granting a depletion allowance to write off the cost of mineral rights ; giving a depreciation allowance for non-industrial buildings, and converting profits tax into a flat rate tax.

Finally, the Association of British Chambers of Commerce says that the Budget should not increase income tax ; to increase it would be a confession of weakness in dealing with expenditure. Taxes on earnings and production should be reduced in priority to taxes on consumption. It is also urged that credit restraint should not be regarded as permanent. If it does not achieve results quickly, the Association comments, other remedies are needed instead.

### Monopolies Commission Report on Industrial Gases

Last week, H.M. Stationery Office published the report of the Monopolies and Restrictive Practices Commission on oxygen, dissolved acetylene and propane. About oxygen and dissolved acetylene, the Commission says in the report that there is no evidence to suggest that the efficiency, technical or otherwise, of the British Oxygen Company, Ltd., falls below the standard which might reasonably be expected of a company of its standing and resources. The Commission does not find it possible, however, to reach a definite conclusion on whether the existing research activities of the British Oxygen Company, Ltd., are adequate. The report remarks that in view of the company's " almost complete monopoly," the Commission attaches great importance to a " substantial effort in the field of research."

The report sets out various detailed conclusions, among which there are included recommendations on plant and equipment, the taking over of other producers, profits and prices, and price scales and methods of charging. The Commission then says it considers that the British Oxygen Company, Ltd., should be left with as much freedom as is compatible with the need to safeguard the public interest, and that this object would be best secured by an arrangement under which the Board of Trade or other competent authority would be able to satisfy itself by periodical reviews that effect was being given to its recommendations. Such reviews, the report continues, should take place at intervals of two or at most three years, the Board of Trade having access to all the necessary information relating to process costs and profits, though the primary responsibility would rest on the British Oxygen Company, Ltd., to show that full effect was being given to the recommendations. The report adds that " there is no power at present under section 10 of the Monopolies and Restrictive Practices (Inquiry and Control) Act, 1948, to enforce such arrangements, but it is not for the Commission to express a view as to whether legislation would prove to be necessary in practice."

# Continental Engineering in 1956

No. II—(*Concluded from page 34, January 4*)

## Railway Developments in France and Germany

TRAFFIC on the French railways is reported to have reached a new high level in 1956. Goods traffic amounted to 49,200 million tonne-km (7 per cent above 1955 and 85 per cent above 1938), and passenger traffic totalled 28,500 million passenger-km (5 per cent above 1955 and 30 per cent above 1938). This achievement must be viewed against the steady reduction which has occurred in the numbers both of employees and of locomotives (1938, staff 514,000, locomotives 19,000; 1955, staff 374,000, locomotives 11,600; 1956, staff 366,000, locomotives 11,500). The productivity of the French railways, expressed as (passenger-km +tonnes-km) : (hours worked) has thus increased from 50 in 1938 to 92·7 in 1955, and 101 (provisional figure) in 1956. This steady progress is the result of the long and patient work of modernisation and rationalisation which has been carried out since the war. An outstanding part of this work has been the replacement of steam by electricity and diesel traction.

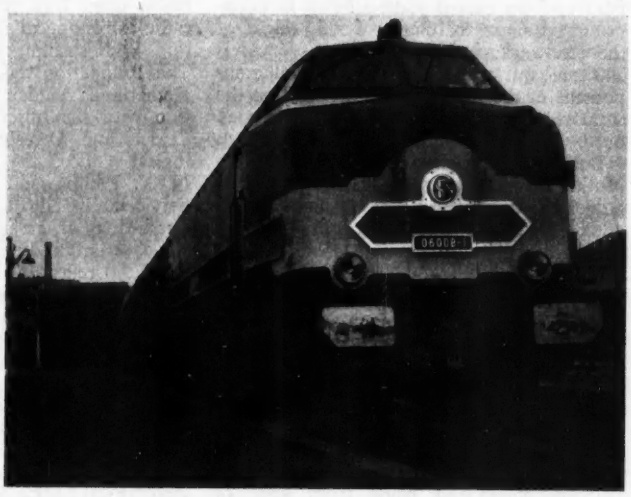
In 1956, 447km of new electric lines were commissioned, including Pontarlier - Les Verrières (11km at 15,000V, 16⅔ c/s); Dijon–Dôle and Bellegarde–Geneva (64km at 1500V d.c.), and 372km of extensions to the 25,000V, single-phase, 50 c/s system (Luxembourg frontier Thionville-Metz-Strasbourg; spur lines in the Lorraine basin; Remilly–Forbach–Saar frontier). Further electrifications are in hand: Paris-Lille, Strasbourg-Basle, and Dôle–Vallorbe, at 25,000V, 50 c/s; Lyon–St. Etienne and Lyon–Tarascon–Nîmes at 1500V d.c. (since these lines are extensions of the existing Paris–Lyon d.c. system).

Results on the line Lille–Thionville, which operates with industrial frequency, are stated to have exceeded expectations. Not only was the system cheaper than 1500V d.c., but it made possible the construction of locomotives, which, for the same weight, had a better performance, a striking example being the "B.B.12,000" with ignitron rectifiers.

At the end of 1956, the S.N.C.F. electrifications totalled approximately 5400km, carrying 39 per cent of all rail traffic, and a further 1000km were being converted. Provided the necessary credits are obtained, it is hoped to continue for the next ten to fifteen years at the rate of some 200km of electrifications per annum. Of a total order for twenty main line deisel engines, which weigh 120 tons and develop 2000 h.p., sixteen have so far been commissioned. Orders have also been placed for twenty diesel-electric locomovites of 1800 h.p. for the south-west, the first of which (shown above) began its trials last October.

As regards rolling stock, carriages equipped with air-conditioning plant were introduced on the "Mistral" trains, all of which will be so equipped in the course of this year. Long distance diesel-car trains, similar to those introduced in 1954, but more powerful (825 h.p.), and more comfortably equipped, were introduced on the routes Paris–Zurich, Basle–Brussels, and Lyon–Milan, and will form part of the "Transeurop" expresses as from June, 1957.

Rolling stock for general purposes is becoming more and more standardised, while, on the other hand, special designs are evolved for particular purposes (automobile transporters, wagons with sliding roof, refrigerator wagons, &c.). The most recent introduction (December, 1956) is a low-platform transporter for commercial road vehicles of all kinds, including long-distance heavy vehicles and their trailers.



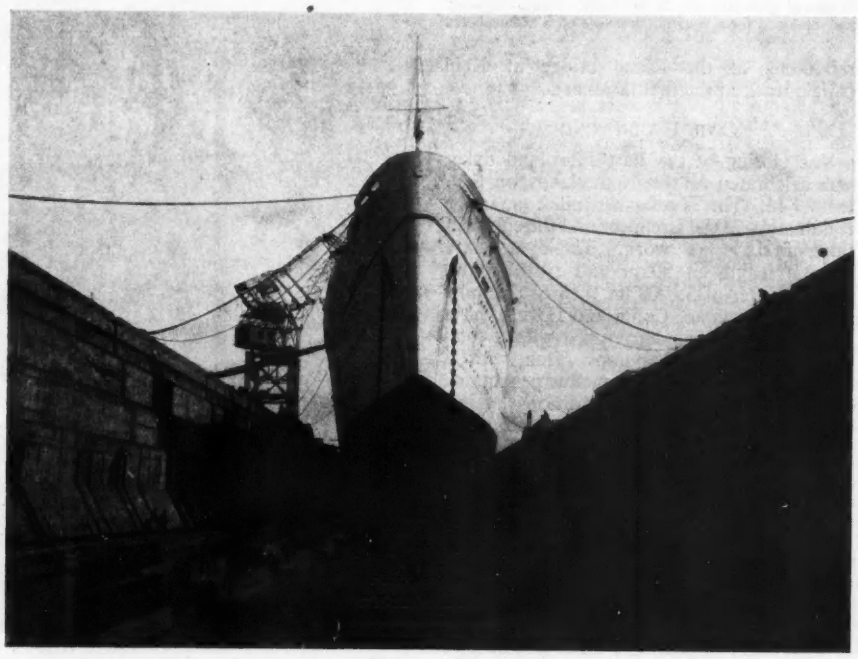
**1800 h.p. diesel-electric locomotive, type "060DB." Two generator sets of 900 h.p. each, arrangement $C_0$-$C_0$, individually driven axles, total weight 105 tonnes, maximum speed 130km per hour**

Substantial increases in traffic on the German Railways (DB) could not entirely be handled by the commissioning last year of forty-six electric and 173 diesel traction units, and it became necessary to reinstate forty-four steam goods locomotives from the reserve. Although steam engine mileages have shown no decrease so far, their percentage proportion of the total traction mileage has shown annual decreases, since 1950, of the order of 2 to 3 per cent, and is now only 74·2 per cent (1950=90 per cent). Additional electrifications amounted to 107km, including the line from Freiburg to Offenburg. Altogether, 2160km have now been electrified. Another 1180km are scheduled for electrification by the end of the current year, so that 10·8 per cent of all German lines will then be electric.

Diesel traction units put into service included fifteen "V65" branch line locomotives and 158 railcars; delivery of the fifty "V200" express locomotives and the 279 "V60" shunting engines has commenced and will be completed by mid-1957. Long-distance railcar trains equipped with 2×1000 h.p. are under construction. The proportion of damaged goods wagons (3 per cent) reached a new low level; 4500 wagons were withdrawn during the year, so that with new deliveries amounting to 11,475 (to October 20) there has been a net increase of about 7000 (compared with only 1500 in 1955).

Electrification and dieselisation has reduced the demand for repair facilities. Of nine repair depots which are to be closed in the first instance, eight have now been shut down. Conversion to electric and diesel work in the other depots is progressing, with much stress being laid on improvements in materials handling.

Further increases in traffic are reported on the German Railways, amounting to 9·8 per cent more passenger-km and 8 per cent more ton-km than in 1955 (by the end of July and August respectively); but only as regards goods traffic did an increase in services become necessary. The number of employees increased to 495,000 (excluding

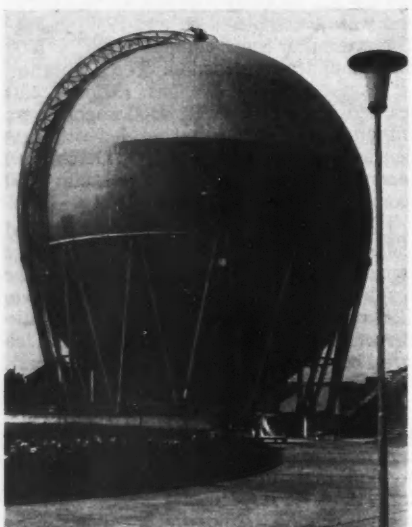


**Naples dry dock, with T.S. "Conte Grande," length 349m, width 45m, depth of water 13·5m**

trainees), and productivity showed further improvement.

For the first time since the war repairs to track approached technical requirements ; the work included new rails for about 600km of track and new sleepers for about 2300km. In addition, some 4000 points were replaced. A total of 36,000 personnel was engaged on this work, which has been further mechanised. Up to 6000km (14 per cent) of rails and points are now welded. Bad stretches necessitating speed reduction decreased from 1800km to 1700km ; rail fractures increased from 5300 in the first half of 1955 to 7900 in the same period last year, of which 2500 occurred in February.

Structural work had to take second place because of the need for track improvements taking precedence. The centre of activity here lay again in the reconstruction of destroyed or damaged bridges. There are still some 360 bridges incorporating 775 temporary structures which for the most part require urgent replacement. Among important completions must be mentioned the rebuilding of the Rhine bridge at Kehl (single-track in the first instance).



**Spherical gasholder of 20,000 cubic metres capacity and designed for a working pressure of 5 atmospheres**

### Civil Engineering

The closing of the East Flevoland dykes was celebrated in the Netherlands on September 13. This is a further milestone in the reclamation of the Isselmeer and the culmination of six years' work. The dykes have a total length of 90km and surround an area of water of 55,000 ha. Three pumping stations, Wortman, Colijn and Lovink, have been constructed and equipped with a total of eight centrifugal pumps, each with a capacity of 500-600 cubic metres per minute (under present pumping conditions against minimum head). These pumps will lower the water level at the rate of about 1cm per day.

Last February the new dry dock at Naples was completed. It has a maximum length of 1150ft, a working width of 148ft and a depth over the sill of 44·3ft, and is illustrated on page 73. Entrances are at both ends. A total of three caisson gates have been provided so that the dock can be divided into two portions, which can be used independently. The dock has three main pumps, each capable of delivering 700,000 cubic feet per hour. They are vertical centrifugal pumps, driven by 1100 h.p., 2kV electric motors. In addition there are three draining pumps of 81,000 cubic feet per hour capacity. For the electric supply to the dock two substations have been installed with voltages of 9kV and 2kV, and 380V, 260V and 220V. Six capstans of 5 ton and 10 ton capacity have been fitted, and there is one electric crane of 12·5–25 tons. Fresh water and compressed air are distributed from central supply stations. The dock, which was built by Navalmeccanica S.A., of Naples, is stated to have cost about £5,700,000 and required 2,500,000 man-days.

In our issue of October 5 we described the radio and television mast at Steinkimmen, between Bremen and Oldenburg, which, with an overall height of 298m, is the second highest structure in Europe after the Eiffel Tower. It comprises a main section constructed in the form of a tube 2m in diameter, with a lattice girder top section 31m long. Besides having high strength, the tubular construction has the advantage of low wind resistance and made it possible to install the lift in a protected position. The shell was built up from curved plates varying in thickness from 6mm to 10mm. Total weight of the steelwork, including the guy ropes, is 240 tons, but together with the vertical components of the rope tension, the load on the support is 387 tons. The work was carried out by Hein, Lehmann and Co., Düsseldorf.

Built for the medium-pressure gas system of the city of Cologne, the spherical gasholder shown here (one of three) has a volume of 20,000 cubic metres and is designed for a working pressure of 5 atmospheres, so that it has a capacity of 100,000 cubic metres of gas. Built by Aug. Klönne, Dortmund, and Pintsch-Bamag A.G., Giessen, the container has a total weight of 950 tons, that of the sphere amounting to 805 tons. The container has a diameter of 33·7m and is built up of seven horizontal zones and two end segments, the equatorial zone consisting of thirty sheets and the others of twenty-four and sixteen sheets respectively. The shell is 28·5mm thick and made from steel of 50-60 kg per square millimetre ultimate strength, 24-20 per cent elongation and 7mkg per square centimetre impact strength. Assembly by welding of the individually tested sheets was carried out at the site. During this process the sheets were held in position by curved fingers, two of which were attached to each individual section, and a number of adjustable wire cables, the other ends of which were fixed to a ring at the centre of each zone. All the welds, totalling 1700m, were X-rayed, requiring 4000 exposures. Since normalising could not be carried out, about 70-80 per cent of the weld stresses were removed by applying heat so as to induce thermal stresses to the extent of causing plastic flow in the weld regions. After testing to 1·1 times the maximum working pressure, the gasholder was ready for filling. Before gas could be introduced 85 per cent of the air had to be replaced by carbon dioxide so as to obtain a non-inflammable mixture ; this required about 54 tons of $CO_2$.

In our issue of November 23, page 749, we described the 25m radio telescope of Bonn University, which was commissioned last year. Even earlier, the instrument shown below came into service at the Dwingelo radio-astronomical laboratory of the Stichting Radiostraling van Zon en Melkweg. This foundation was formed in 1949 by the Netherlands Academy of Science in co-operation with the observatories of Groningen, Leiden and Utrecht, the Royal Meteorological Office, the science laboratory of N. V. Philips, and the Post Office Radio Service and Radio Laboratory. While some interesting observations of galactic short-wave (21cm) radiation were obtained with the 7·5m reflector at Kootwijk, the need of greater resolving power led to the construction of the present equipment. The reflecting surface consists of wire mesh and is thus not visible on the photograph ; the very stringent requirement for correct focusing is that any deflections must be within 1cm of the true parabolic shape. The mirror is made of steel and is held in an azimuth support, the tower rotating on a circular rail track. The work was carried out by Werkspoor, (Utrecht and Amsterdam).

**Radio telescope at Dwingelo, with 25m diameter reflector**

# The American Scene

BY OUR AMERICAN EDITOR

## Shortage of Engineers

AMERICAN industry's annual manhunt is under way once more. The employment offices at universities across the United States are the scene of feverish activity, and the "talent scouts" are already making their sales pitch for the services of the June graduates. With industry currently expanding its research and development programme, engineers, scientists and technicians are being wooed more ardently than ever. This competition for talent is forcing starting salaries about 5 to 10 per cent higher than last year, and the engineers graduating next June will average 450 dollars a month upon commencing industrial employment. There is no easy or quick way to overcome the shortage of scientists and engineers that has become a threat to the national security and economic progress. The solution can come only through diligent efforts extending over several years to bring the supply of technically trained people into balance with America's needs. Meanwhile, the pressure of the shortage can be relieved if industry, the government and the universities make better use of the limited number of scientists and engineers now available. It is clear that no "crash programme," inspired by panic and designed indiscriminately to drive hordes of high school students into science and engineering, is suitable for the United States. Any such programme, whether it involved totalitarian methods or simply overselling the advantages of technical careers, would be objectionable. It would jeopardise the quality of scientific and engineering training. It would put many young people in fields where they have little aptitude and deny them to other fields for which they are better equipped. And, if carried too far, it might even result in the overcrowding that was feared prematurely a few years ago. It is now generally agreed that the most important problems for the long run are in the area of education. Any real solution must reduce the loss of talented high school graduates who do not continue their education for financial reasons or because of lack of interest. Also, it must improve the quality of high school preparation in science and mathematics and, above all, relieve the critical shortage of teachers.

Substantial increases in the salaries of teachers in most American school systems are essential if high school students are to receive adequate preparation for courses in science and engineering. Pay scales that have lagged behind rising living costs and salaries available in industry have placed great strain on even the most devoted teachers. There has been a sharp drop in the number of new graduates trained to teach science and mathematics, and of this smaller number many have decided not to follow careers in teaching. Raising teachers' salaries to more realistic levels must be primarily the job of local school boards, aided by State governments. If, in the face of rapid increases in school enrolments, local and State resources prove insufficient, then federal aid will have to be considered. At the college level also financial aid is needed to provide scholarships for promising students and to increase faculty salaries. But not all the educational problems related to the shortage of scientists and engineers can be solved with money. Science and mathematics have steadily been de-emphasised in America as more youngsters have gone to high school for terminal education rather than for college preparation. This de-emphasis must be reversed. Techniques of instruction, furthermore, can stand improvement at all levels of education. Professor E. P. Northrup, of the University of Chicago, observes: "In the past fifty years . . . there has been a revolutionary change in the character of mathematics, yet not a trace of this change is to be found in the curricula of all but a handful of secondary schools throughout the country." Colleges and universities may have to examine old fetishes about light teaching loads and small classes in order to make more efficient use of their faculties.

Industry itself has the immediate problem of a better utilisation of the available technical manpower and the long-range responsibility of helping to increase the country's pool of trained people. Frantic recruiting practices and reckless bidding up of starting salaries—financed largely by government money for defence orders—are not the answer. There is need for an earnest consideration of incentives for experienced scientists and engineers, who too often must look to sales or executive positions for adequate financial recognition. It is frequently heard now that industry in many instances could make more efficient use of engineers and scientists by shifting work to technicians, clerical personnel and even machines. One company found that 15 per cent of the time of an engineering design group was spent on routine jobs and that this valuable time could be saved by adding a technician and a clerical worker to the group. Other potential sources of technical manpower could be tapped more extensively to relieve the shortage. Very few women have entered what has been traditionally a man's world. Negroes are only slowly gaining educational and employment opportunities in technical fields. And many experienced older men can still give useful service. Much is being accomplished already in efforts to attract more young people into scientific and engineering careers, and the professional engineering institutions are playing an important part in this work. Results are beginning to appear in the rising enrolments in engineering colleges and technical institutes. Between 1951 and 1955, according to McGraw-Hill's annual survey of technical institutes, the enrolments in these institutions rose from 46,000 to a record 67,000. Engineering enrolments at universities rose in the same period from 166,000 to 243,000. Thus a rising tide of graduates is already being made available to American industry. This is a good beginning. But only with a wider appreciation of the serious implications of the shortage of scientists and engineers and intensified efforts on the part of industry, government and education to relieve the shortage can America hope to overcome this threat to her national security and economic well-being.

## Export of American Research Reactor to Japan

THE U.S. Atomic Energy Commission has issued a licence for the export of a research reactor to Japan, constituting the first such commercial transaction in the history of the private atomic energy industry in the United States. The licence was issued to the New York firm of Marubeni-Iida for the export of a reactor fuelled by an aqueous solution of uranyl sulphate and operating at 50kW, for use in Japan by the Japan Atomic Energy Research Institute. The Atomics International Division of North American Aviation, Incorporated, is manufacturing the reactor at Canoga Park, California, and will deliver it to Marubeni-Iida for export from a Pacific Coast port. The granting of the licence is based on a determination that it is within the scope of and consistent with the bilateral agreement for co-operation between the Governments of the United States and Japan, which has been in effect since December, 1955.

The Japan Atomic Energy Research Institute, which was formed in 1955 as a central organisation for research and development and reorganised in June, 1956, into a special corporation, is supported both by the Japanese Government and private interests. It is concerned with basic studies in atomic energy, the collection of data on atomic power, the design, construction and operation of facilities, the training of nuclear scientists and engineers and the importation, distribution and use of radioactive isotopes. The Institute is now engaged in construction on a 900-acre site in Tokai Village, about 80 miles north-east of Tokyo, where the Institute will have its headquarters and the reactor will be situated. While the reactor to be shipped to Japan will be the first to be sold directly by American industry, it will represent the second United States-built reactor to go into operation abroad. A pool reactor designed and built at the Oak Ridge National Laboratory was exhibited by the United States Government at Geneva in August, 1955, during the International Conference on Peaceful Uses of Atomic Energy, and later was sold to the Swiss Government. It has been reassembled at a research centre near Zurich. Three additional applications for licences to export research reactors are pending before the Commission. Two have been filed by A. M. F. Atomics, Incorporated, of New York, covering the export of a pool reactor to Munich, and a light-water moderator reactor to be erected at an international exhibition in Amsterdam. The third pending application is by the Babcock and Wilcox Company, of New York, for the export of a pool reactor for erection at the University of Sao Paulo in Brazil.

## Research Reactor for Venezuela

Two American firms have been selected to design and manufacture, and to provide consulting engineering services for, Venezuela's first atomic reactor. The General Electric Company, of Schenectady, New York, will design and manufacture a research reactor rated at 3MW of heat, while the General Nuclear Engineering Corporation, of Dunedin, Florida, will act as consulting engineers for experimental requirements and design of the housing for the reactor. The reactor will be used by the Venezuelan Biophysics and Nuclear Physics Research Centre for research in the fields of biophysics, medicine, physics, chemistry and bio-chemistry. Other applications will include the production of radioactive isotopes and general nuclear training.

The reactor will be of the "swimming pool" design. Its fixed core will be submerged in a pool of ordinary water, which will both cool and moderate the reactor. The reactor can be modified to operate at 5MW of heat if the need arises. The research reactor will incorporate an exceptionally wide variety of experimental facilities. These will include six removable neutron beam ports with vertical shutters, two through-ports, six vertical ports, two thermal columns, and four "in-core" radiation baskets for isotope production. The reactor will use fuel enriched to 20 per cent in the isotope uranium 235, which can be made available by the A.E.C. under the Atomic Energy Agreement between Venezuela and the United States.

# American Water Power Schemes in 1956

No. II—(*Concluded from page 37 January 4*)

## Garrison Dam

With its earth-fill embankment impounding water and its turbo-generators producing electricity, the Garrison dam and reservoir on the Missouri River in North Dakota is practically complete. Details of this important scheme of the U.S. Army Corps of Engineers, which is to serve for flood control, power generation, irrigation, navigation and stream sanitation, are shown in Fig. 5. At maximum normal operating level the Garrison reservoir will have a total capacity of 23,000,000 acre-feet ; covering a length of 217 miles, a maximum width of 14 miles and an area of 390,000 acres. It is believed that this will make it the largest man-made lake in the world. The dam is a rolled earth-fill structure, which is 12,000ft long at the crest, with a maximum height of 210ft and a maximum base width of 2600ft. The crest width is 60ft and the side slopes range from 1 in 8 and 1 in 10 in the lower portion of the embankment to 1 in 2½ in the top portions. The ultimate total volume of the embankment will be 70,000,000 cubic yards, and nearly all the fill materials were obtained from the excavations for the spillway and the outlet works channels. The embankment foundation consists of alluvial sand, extending as deep as 110ft on the east side of the river, and outwash clays with sand and gravel lenses on the west side. Underlying these materials and extending up to or near the surface on both sides of the river is the bedrock formation, which is highly consolidated and consists largely of clayey materials.

A system of outlet works has been provided in the west abutment of the dam for diversion of the river during the closure stage of dam construction and for the permanent control of water. The outlet works consist of eight tunnels through the dam, an intake structure with control gates at their upstream ends, and a stilling basin and power plant at their downstream ends, with excavated channels leading to the river, both upstream and downstream. The eight tunnels are nearly parallel in alignment, are each about 1200ft long, are all circular in cross section and have reinforced concrete linings. Five of the tunnels, each having a 29ft inside diameter, serve as conduits for 24ft diameter steel penstocks leading to the turbines. The three most westerly tunnels serve for reservoir regulation, discharging into a concrete stilling basin ; two of these tunnels have an inside diameter of 22ft and the third tunnel one of 26ft. Each of the three regulating tunnels is served by a single sector gate, 24ft 6in high by 18ft wide. Each of the five power tunnels is served by two vertical lift " caterpillar " gates, each 26ft high by 12ft wide, with a dividing pier between them. The concrete stilling basin is of the design conventionally employed for dissipating the energy of water flowing freely at high velocities from the end of a conduit. It is divided into three units to allow for operation of the three regulating tunnels individually or in any combination. Under maximum head and maximum flow conditions the height of the hydraulic jump in the stilling basin is about 30ft. The overall dimensions of the structure as required to develop and contain the hydraulic jump for all three tunnels are as follows : length 470ft, maximum height of wall above floor of stilling basin 71ft, and width of basin 260ft.

The power station at the dam consists of five 80MW turbo-generator units, three of which have been installed within the initial scheme of construction ; the other two will be installed at a later date. Due to the length of the penstocks, two steel surge tanks, 65ft diameter by 135ft high, were provided on each penstock at a point a short distance upstream from the power station. The turbines are vertical shaft Francis units, having runner diameters of 210½in, rated at 88,000 h.p. at or near maximum efficiency at a 150ft head. The spillway is situated high in the east abutment of the dam, and was completed in August, 1955. Its design capacity is 827,000 cusecs at a reservoir level 16ft below the crest of the dam, and it is of concrete construction, with gate control at an ogee weir at the upstream end, where there are twenty-eight sector gates, each 40ft long by 29ft high, individually operated by electric hoists mounted on the piers.

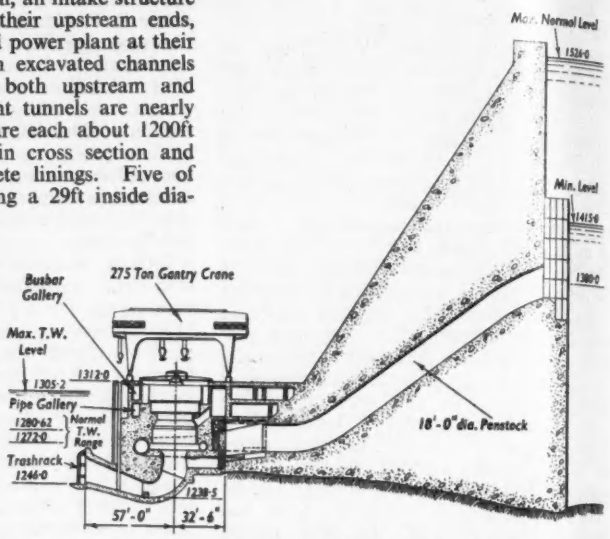



Fig. 6—Cross-sectional elevation of pump-turbine unit at the Hiwassee dam of the Tennessee Valley Authority

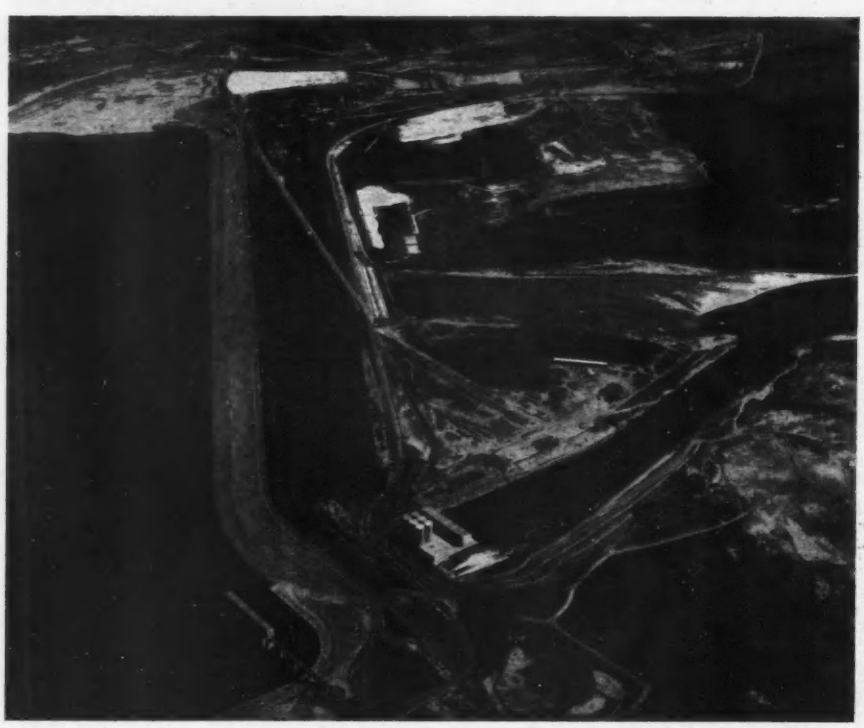


Fig. 5—Aerial view of the Garrison dam of the U.S. Army Corps of Engineers on the Missouri River in North Dakota

## Hiwassee Dam

On May 24, 1956, the large pump-turbine unit at the Hiwassee dam of the Tennessee Valley Authority, which is shown in Fig. 6, went into full operation. For pumping operation, the unit is rated as a 102,000 h.p. motor driving a centrifugal pump ; for generation, it is rated as an 80,000 h.p. turbine driving a 59·5MW generator. As a turbine, the unit draws 4250 cusecs of water at a 190ft head. As a pump, the unit delivers 3900 cusecs of water against a 205ft head. The ratings of the machine are : (1) as a motor, 102,000 h.p., 80 deg. Cent. rise of temperature, 0·95 power factor leading, 13·5kV ; (2) as a generator, 70MVA, 60 deg. Cent. rise of temperature, 0·85 power factor lagging, 13·8kV. The unit normally turns at 105·9 r.p.m., and the turbine diameter at the centre line of the distributor measures 266in.

The new unit raises the station rating by

its own rated capacity of 59·5MW. During the winter peak-load season the new unit will have 8500kW more dependable capacity than an equal-sized conventional unit. Near the end of the critical peak-load period, the additional capacity of the station could amount to as much as 44,000kW. The principal value of the machine is the peaking capacity it can add to the system capability during the critical load period. In addition, during a dry year the station capability rises substantially, while a conventional unit would add very little.

As a turbo-generator, the new machine will be started in the same manner as its companion turbo-generator at Hiwassee. As a pump motor the starting sequence differs in several respects : after closing the wicket gates, compressed air forces the tail-water level below the pump-turbine runner. The motor generator then starts electrically powered and accelerates to normal speed with the runner turning in air. Reducing the air pressure allows the tail-water to rise and refill the draught tube. Opening the wicket gates puts the pump into full operation, discharging water up the penstock into the reservoir.

The machine turns clockwise when generating and counter-clockwise when pumping. About 3kW can be generated by the set for every 4kW used in pumping. It is believed that the pump-turbine will have no adverse effect on fish life. The same number of fish will survive a trip through a pump-turbine as through a conventional turbine runner. It has been found that fish do not tend to travel into the pump intake during pumping operation as they do into a turbine inlet during generating operation.

### Rockslide at Schoellkopf Power Station

Figs. 7 and 8 illustrate one of the worst disasters to occur in the field of hydro-electric power generation in recent years. It happened on June 7, 1956, at the Schoellkopf power station of the Niagara Mohawk Power Corporation on the Niagara River at Niagara Falls, New York. The rock fall, which took place in a matter of moments, destroyed 234MW of the 335MW capacity of the station and left the other 101MW flooded under 10ft of water. Trouble first became apparent at 10.30 a.m., when water was noticed on the floor of Section C, the newest part of the structure. It was decided to shut down Unit 21, a 52MW generator, so that the source of the water might be found. Seepage continued throughout the day, despite the efforts of a work force of more than forty men to halt the water and divert its flow from the station.

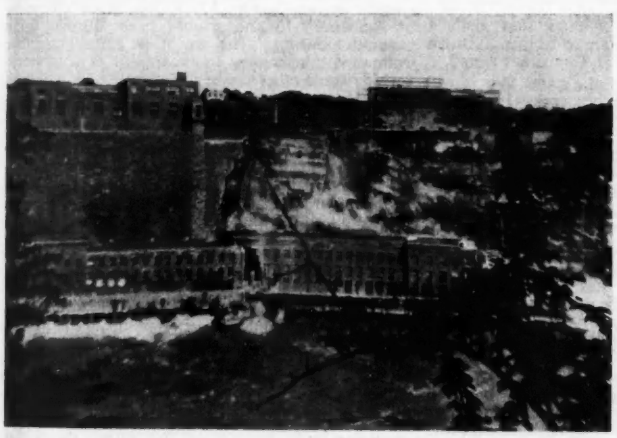


Fig. 7—Rockslide at the Schoellkopf power station of the Niagara Mohawk Power Corporation on June 7, 1956

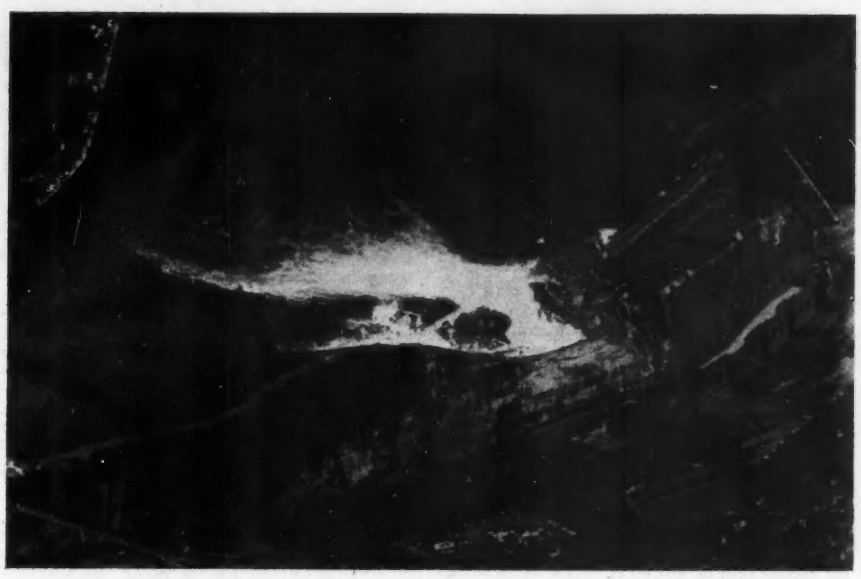


Fig. 8—Aerial view of disaster site, showing two-thirds of the power station destroyed

Shortly after 5 p.m. a crack appeared in the southernmost wall of Section C. The wall began to "tip away" from the station. Within seconds tons of rock and water began to fall from the gorge wall above. The workmen had been warned of impending danger by falling stones and a rumbling sound. More than twenty-five men, who had been on the roof, scrambled across Sections B and A to the bank of the gorge northward. In flight they left a trail of discarded jackets and hats. Nine station operators who had been in the generating rooms met this group at the north station door, propped open earlier to ensure safe exit. All made their way to safety downriver. One man was able to ascend in the lift to within 18ft of the cliff top, but had to be hoisted by rope the remaining distance when the lift power gave out. At the south end of the station, three men were examining the stone face of the cliff for further leakage when the sudden rush of water swept them into the Niagara River. Two of the men somehow clambered to shore but the third man was lost in the river.

Estimates have been made that as much as 120,000 tons of rock, including boulders as big as a house, fell in three crushing slides during a fifteen-minute period. The slide was compared to one at Prospect Point in 1954, when 180,000 tons of rock, loosened from the bank by water seepage, fell from above the Niagara Falls. When the dust of the last rock slide finally lifted it was clear that the tremendous rockfall had completely demolished two of the station's three sections. The third section remained standing, but damage was severe. Tons of water battered, twisted and tore at the steel and stone of the station, driving much of it into the 180ft deep gorge. A wide tongue of water surged from the penstocks and slapped violently at the ruins.

The arrangement of part of the power station made it impossible to cut off the flow of water through the penstocks from the canal and tunnel for several days. The flow from the ruptured penstocks ran through and over the rubble flooding Section A to a depth of 10ft. Steps were taken promptly to de-water the canal and tunnel by means of a cofferdam built at the intake 2 miles above the falls. The City of Niagara Falls was without power for about eight hours following the slide. But by 2 a.m. of the following day service to all customers was fully restored by drawing on grid interconnections with the Ontario Hydro-Electric Power Commission, the New York State Electric and Gas Corporation, the Rochester Gas and Electric Corporation and others.

## Expansion of Mellon Institute

The Mellon Institute, of Pittsburgh, Pennsylvania, which is the oldest scientific research institute in the United States, has announced plans for the construction of a laboratory to house its recently established Department of Radiation Research. The two-storey laboratory structure will be built on a 125-acre rural site situated about 20 miles east of Pittsburgh, near the town of Export, in Westmoreland County, Pennsylvania. The Mellon Institute was founded in 1913 through the generosity of Andrew W. Mellon and Richard B. Mellon. It carries out fundamental research in the natural sciences, aimed at long-range professional and industrial development, and is the home of the Mellon Institute Fellowships. These Fellowships are maintained by American industrial companies, the Federal Government, and by foundations to conduct research, aimed at developing new products and new processes. The new suburban research centre represents the first major expansion of facilities for the Institute since the completion of its present large laboratory building, close to the University of Pittsburgh, in 1937.

The construction of the radiation research building is expected to be completed by late summer. It will house the Institute's first major source of radiation, a powerful 3MeV Van de Graaff accelerator which is now on order from the High Voltage Engineering Corporation at Cambridge, Massachusetts. Pending the installation of the Institute's own particle accelerator, arrangements have been made for the part-time use of a similar radiation machine now installed in the Pittsburgh area. Also included will be laboratories for radio-chemical and allied work, general laboratories, office space, and a radiation library.

# Personal and Business

## Appointments

MR. H. S. MALIK has been appointed special director (India) of Simon-Carves, Ltd.

MR. W. J. M. ADAMS has been appointed managing director of Worthington-Simpson, Ltd.

MR. W. A. KNIPE has been appointed a director of Sciaky Electric Welding Machines, Ltd.

MR. W. H. LINDSEY has been appointed technical director of Armstrong Siddeley Motors, Ltd.

MR. J. E. ORAM has been appointed managing director of Wild-Barfield Electric Furnaces, Ltd.

MR. H. F. TREMLETT has been appointed deputy director of the British Welding Research Association.

MR. W. C. F. HESSENBERG has been elected a member of the council of the Iron and Steel Institute.

MR. R. E. W. HOLMES has been appointed regional sales manager for the south-western region of A. C. V. Sales, Ltd.

LIEUT.-COL. L. A. M. BATES-OLDHAM has been appointed a special director of International Combustion, Ltd.

THE BRITISH TRANSPORT COMMISSION has announced the appointment of Mr. G. H. Hinds as electronics advisory officer.

MOBIL OIL COMPANY, Ltd., has announced that Mr. J. A. Paul and Mr. F. P. Barribal have been appointed directors.

MR. H. G. TAYLOR has been appointed director of the Electrical Research Association in succession to the late Dr. S. Whitehead.

MR. J. F. RICHARDSON has been appointed technical secretary of the Radio Communication and Electronic Engineering Association.

MR. R. WRIGHT has been appointed engineering castings representative in Scotland of The Carron Company, in succession to Mr. J. Wilson.

MR. R. B. F. WYLIE has been appointed director of the Copper Development Association. Mr. G. W. Preston, general manager, has retired.

LONDON TRANSPORT has announced the appointment of Mr. A. G. Evershed as a chief officer of the Executive. His title will be commercial manager.

THE DE HAVILLAND ENGINE COMPANY, Ltd., has announced the appointment of Mr. J. M. Nicholson as chief test pilot in succession to Mr. C. D. Beaumont.

THE BRITISH TRANSPORT COMMISSION announces the following appointments: Mr. L. J. Hamblin, industrial relations and welfare officer; Mr. G. H. K. Lund, work study assistant.

THE MINISTRY OF SUPPLY announces that Mr. E. E. Haddon has been appointed director of chemical defence research and development in succession to Mr. A. E. Childs, who is retiring.

MR. PERCY CUDDINGTON has been appointed chief engineer of T. Wall and Sons (Ice Cream), Ltd., The Friary, Acton. He has been succeeded at the Godley factory by Mr. Alfred Slingerland.

SIR PATRICK HENNESSY has relinquished his appointment as managing director of the Ford Motor Company, Ltd., but continues as chairman. Mr. C. Thacker has been appointed managing director.

THE BRITISH OXYGEN COMPANY, Ltd., has announced that Mr. Edgar Stewart Lane, northern area sales manager of the medical division, has retired. He has been succeeded by Mr. Frederick B. Stephens.

CAPTAIN W. A. HANN has been appointed principal officer in the London district office of the marine survey service of the Ministry of Transport and Civil Aviation, in succession to Captain A. C. Kidd, who is retiring.

THE MINISTRY OF SUPPLY has announced the appointment of Mr. E. A. Poulton as director of aircraft mechanical engineering equipment research and development, in succession to Mr. R. Graham who is retiring.

MARKHAM AND CO., Ltd., has announced that Mr. Arthur van Rhee has been appointed a director and will take over the post of works director in succession to Mr. F. Williams, who continues to serve on the company's board.

MR. G. N. BRIDGE has been appointed a director of Associated British Oil Engines (Export), Ltd., Brush Export, Ltd., and National Oil Engines (Export) Ltd. He will continue to serve as London manager of the Brush Group.

THOS. W. WARD, Ltd., has announced the following appointments as local directors: Mr. Ernest Springthorpe, Mr. C. Norman Bradshaw, Mr. Eric Wolstenholme, Mr. George Page, Mr. Reg. Hadfield, and Mr. Alfred Kissack.

MR. H. H. PHILLIPS has been appointed a member of the Transport Tribunal for a period of five years, in succession to Mr. A. E. Sewell, whose appointment has expired. Mr. Sewell has been appointed a member of the special panel of the Tribunal.

LEYLAND MOTORS, Ltd., has announced that Mr. C. B. Nixon, chairman of the Leyland Group since 1942, is retiring, but will remain a director. Sir Henry Spurrier has been appointed chairman and retains his present office of managing director.

BLACK AND DECKER, Ltd., announces the following appointments:—Mr. Leo Long, European sales manager; Mr. Ken Gahagan, Mid-African representative; and Mr. Bill Downing, regional sales manager (utility) for the London and eastern region of England.

MR. C. R. CORNESS has been appointed secretary of Taylor Woodrow Construction, Ltd., in succession to Mr. L. Daniels, who continues as secretary of the parent company, Taylor Woodrow, Ltd. Mr. Leslie G. Cann has been appointed deputy chief surveyor of Taylor Woodrow Construction, Ltd.

AUTOMATIC TELEPHONE AND ELECTRIC COMPANY, Ltd., announces that Sir Thomas Eades has been appointed chairman of the company in succession to Sir Alexander Roger, who has retired. Sir Alexander Roger has been appointed honorary president. Mr. C. O. Boyse has been appointed managing director.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., has announced the appointment of Mr. W. Spence, M.I.E.E., as manager, industrial engineering department, in succession to Mr. W. J. Pool, A.M.I.E.E., who has relinquished the appointment in order to devote full time to special duties with the company.

WOODALL-DUCKHAM CONSTRUCTION COMPANY, Ltd., has announced that Mr. D. Rider has resigned his position as joint managing director and has retired from the board. He remains a director of the parent company, Woodall-Duckham, Ltd. Mr. F. P. Dyson, M.I.C.E., has been appointed joint managing director, and Mr. C. D. Muntz, M.I.C.E., and Mr. E. N. Wenborn, directors.

## Business Announcements

GROUP CAPTAIN C. S. MORICE, sales manager of Dunlop's aviation division, has retired.

JOY-SULLIVAN, Ltd., states that its London and export office has moved to 7, Harley Street, W.1 (telephone, Langham 7711).

FOLLAND AIRCRAFT, Ltd., states that Folland "Gnat" lightweight fighters are to be manufactured under licence by Valmet Oy at Tampere, Finland.

WEINREB AND RANDALL, Ltd., states that it will move to new premises on February 1. Its address will be Watchtower Works, Greenside Road, Croydon (telephone, Thornton Heath 8696).

MR. M. E. ADAMS, civil-engineer-in-chief of the Admiralty, is being lent to the Governors of the Federation of Nigeria and of the Western Region to advise on their public works service. He will leave for West Africa at the end of January.

HOLMAN BROTHERS, Ltd., Camborne, and BROOM AND WADE, Ltd., High Wycombe, are arranging a merger. This arrangement has been designed to assist the export business of the two companies and to allow the Holman factories in South Africa and Australia to maintain the equipment of both companies overseas.

THE EXPORT CREDITS GUARANTEE DEPARTMENT announces that its West London office has moved to Romney House, Marsham Street, London, S.W.1 (telephone, Abbey 6271). This office covers the London postal districts of N.W., W., and S.W., and the counties of Middlesex, Surrey, Sussex, Hampshire, Berkshire, Buckingham and Oxford.

## Contracts

F. G. MILES, Ltd., is to build a flight simulator for pilot training on the D.H. 110 all-weather naval fighter for the Ministry of Supply. The company has previously built simulators for the Gloster "Javelin" and Hawker "Hunter."

THE ENGLISH ELECTRIC COMPANY, Ltd., has received an order to supply seven 750 h.p. diesel-electric locomotives to the Midlands Railways of Western Australia. The diesel engines and electrical equipment for these locomotives will be built at The English Electric Company's Preston Works, and the mechanical parts will be manufactured at the company's Rocklea Works in Australia.

VICKERS-ARMSTRONGS (AIRCRAFT), Ltd., is to supply twenty "Vanguard 952" airliners to Trans-Canada Air Lines, who have also taken an option on a further four. Including aircraft and engine spares, the value of the contract is £23,900,000. The aircraft will be powered by Stage II Rolls Royce "Tyne" propeller turbines of 5315 e.h.p. and cruise at up to 425 m.p.h. Fully winterised and with North American equipment, they will gross 141,000 lb and eighty-two first-class or 102 tourist passengers. Space for 10 tons of freight is also provided; with this payload the range would be 2600 statute miles with reserves.

BRITISH RAILWAYS have announced contracts for the reconstruction of the superstructures of eleven overbridges as part of the civil engineering work in readiness for the Eastern Region electrification of the Liverpool Street to Chingford, Hertford East and Bishops Stortford lines forecast for completion in 1960. A further contract is for the repair and raising of the public overbridge at Clapton station. Five of the bridges are between Hackney Downs and Clapton stations on the Chingford, Hertford East and Bishops Stortford line and the remaining six bridges are between Hackney Downs and Bruce Grove stations on the Enfield Town line. Six superstructures are to be reconstructed by A. Jackaman and Son, Ltd., and five more by Higgs and Hill, Ltd. The repair and lifting of the overbridge at Clapton station will be carried out by Samuel Butler and Co., Ltd.

## Miscellanea

LONG-RANGE AIRLINER.—The first of the long-range Bristol "Britannia" airliners made its first flight late last year. It is a "Britannia" 312 for B.O.A.C.; aircraft of this series carry 8486 Imperial gallons of kerosene to give a range of 6000 miles. 300 series machines will be used by Canadian Pacific and other airlines for year-round non-stop trans-atlantic flights and non-stop Polar services from Europe to the west coast of North America.

"STAHL UND EISEN."—A special issue marks the seventy-fifth anniversary of *Stahl und Eisen* the journal of the Verein Deutscher Eisenhüttenleute. Among many articles of technical and economic interest, the issue surveys the journal's development since 1931, as well as the work of the publishing firm, which includes the *Archiv für Eisenhüttenwesen*, founded in 1927, as a supplementary journal to *Stahl und Eisen* for the publication of the results of fundamental and long-term research in metallurgy and iron and steel technology.

MOULD LUBRICANT.—Amber Oils, Ltd., 11a, Albemarle Street, London, W.1, has given the name "Ambersil" to an aerosol-packed silicone spray mould lubricant. The use of an aerosol dispenser allows a thin coating to be applied of a lubricant which would otherwise be too expensive for industrial use. Formula 1 comprises a pure methyl silicone fluid of high lubricity and low surface tension, which is colourless, odourless, non-toxic and non-volatile. It is chemically inert and water resistant; highly resistant to shear breakdown and oxidation, it has a flashpoint of 600 deg. Fah. and a spontaneous ignition temperature around 900 deg. Fah. Formula 2 is a similar fluid diluted to give an even thinner film and restricted to moulding operations at lower temperatures. "Ambersil" prevents the adhesion of paint and even of weld spatter; it can be removed with carbon tetrachloride, kerosene or similar solvents. It is claimed that, in addition to moulds for thermoplastic and thermosetting resins, it can be used in die casting zinc or aluminium alloys.

UNCONVENTIONAL AIRCRAFT.—The autumn, 1956, issue of *The "Bristol" Quarterly* devotes an article to the problems of heavy helicopters. Concentrating on mechanically-driven rotors because of their superior fuel consumption, the author shows that scale effects dictate a number—two—of lifting rotors, and that these are best arranged in tandem for heavy-lift aircraft. The great weight of engines and transmissions makes it undesirable to attempt to provide sufficient engine-out power to sustain a twin-engine machine in hovering flight, and therefore Bristol have evolved and developed with the "173" helicopter a backward take-off technique for use at restricted heliports. It consists simply of climbing away backwards from the take-off point, so that the landing area is kept in front of the machine. If an engine fails before single-engine safety height has been reached, the pilot can allow the machine to sink back into the ground cushion and land; the climb path would be at about 60 deg. to the horizontal. This issue also contains an account of the development, along lines established by the Boeing Airplane Company, of ramjets by use of a test vehicle with two 6in motors. The far aft position for the engines was chosen in the expectation that the shock emitted from the intake would cause boundary layer separation where it hit the body and increase the friction from there aft.

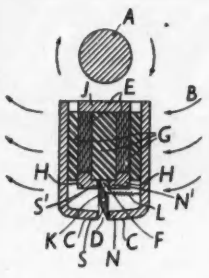
# British Patent Specifications

*When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application, the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.*

## ELECTRICAL ENGINEERING

**763,695.** January 10, 1955.—MAGNETIC DEVICE FOR DETECTING REVERSE CURRENT, Maschinenfabrik Oerlikon, Zürich-Oerlikon, Switzerland. (*Inventor: Bjarne Storsand.*)

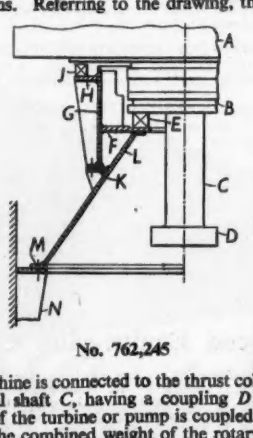
According to the invention a quick-acting magnetic device for indicating reverse current in a rectifier installation is designed to be disposed in the immediate vicinity of the line to be supervised and to respond to the magnetic field produced by the reverse current. The device comprises a permanent magnet system with a small air gap, and a soft iron system, which is magnetised by the magnetic field of the line to be supervised and which, at the same time, serves as a screen to protect the permanent magnet system from becoming demagnetised. A common pivoted armature is provided for the permanent magnet system and the soft iron system, and pivots over on magnetic reversal of the soft iron system caused by the magnetic field of the reverse current. In the drawing *A* denotes the anode conductor; *B* represents the field lines, which are shown for normal operation and which run in the opposite direction in the case of a fault; *C* denotes two soft iron pole shoes having poles *N* and *S* with an air gap *D* between them; *E* denotes two permanent bar magnets having poles $N^1$ and $S^1$ with an air gap *F* between them, and *G* is a copper block in which the magnets *E* are embedded. *H* are soft iron pole shoes and *J* a soft iron yoke for the magnets *E*, whilst *K* is a soft iron pivot armature stressed by a spring *L*. As soon as the direction of the field lines reverses through a fault, the pole shoes *C* of the soft iron system assume reversed polarity and the pivot armature snaps into the position indicated by chain-dotted lines. The pivot armature *K* remains in this position by the action of the spring *L* until it is reset by hand. Resetting may, however, also be effected electromagnetically by means of a small auxiliary magnet. The pivot armature *K* may either actuate a signal or give a signal through an electric contact. The device can also be so arranged that the permanent magnets have their longitudinal axes running parallel to the current conductor, which has the advantage that they could be mounted closer to the axis of the conductor and hence in a more intense stray field.—*December* 12, 1956.




No. 763,695

**762,245.** July 27, 1954.—THRUST BEARING SUPPORTS FOR HYDRO-ELECTRIC VERTICAL SHAFT MACHINES, The English Electric Company, Ltd., Queen's House, 28, Kingsway, London, W.C.2. (*Inventor: George Fritz Werner Adler.*)

The invention relates to thrust bearing supports for hydro-electric vertical shaft machines comprising water turbines and alternators, or pumps and driving motors. The thrust support consists of one or more truncated sheet metal cones transmitting the thrust load from the thrust bearing or jacking points of the hydraulic or electric part of the machine to the foundations. Referring to the drawing, the rotor *A*




No. 762,245

of the machine is connected to the thrust collar *B* and the vertical shaft *C*, having a coupling *D* to which the shaft of the turbine or pump is coupled in such a way that the combined weight of the rotary parts of the machines is transmitted in operation to the thrust collar *B* to a thrust bearing shown diagrammatically at *E*. The thrust bearing rests on the bottom *F* of the oil pot *G*, which has an outer flange *H* near its top, on which rest the diagrammatically indicated jacks *J*, supporting the rotor *A* of the machine, during assembly or dismantling. The cylindrical wall of the oil pot is extended downward below the bottom *F* and rests on a flange *K* welded to the mantle of the sheet metal cone *L*, the upper small end of which carries the bottom *F*. The large lower end of the truncated cone *L* rests with its flange *M* on brackets *N* attached to the concrete foundations, or to a cylindrical support or columns transmitting the load to the foundations. All metal parts components are fabricated by welding, and may be provided with stiffeners and radial joint flanges. Access and ventilation holes may be provided where necessary. Modified designs with two-cone and three-cone supports are also described in the specification.—*November* 28, 1956.

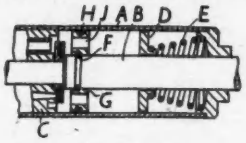
**762,209.** March 4, 1954.—ELECTRIC CABLES AND PROTECTIVE COVERINGS, The Telegraph Construction and Maintenance Company, Ltd., Mercury House, Theobalds Road, London, W.C.1. (*Inventor: Raymond Charles Mildner.*)

The invention relates to corrosion protection for the sheaths of electric cables, particularly characterised by the fact that the protection is a partial conductor of electricity. According to the invention, a metal-sheathed electric cable is provided with a protective covering comprising a plastic, gutta percha, rubber or like non-fibrous dielectric material loaded with conducting material to give a resistivity between 10,000 ohms centimetre and 3 ohms centimetre. The covering is preferably formed by loading the non-fibrous dielectric material with carbon in powder form. By means of such loading the resistivity of the covering may be reduced to the order of that of the earth, so that the metallic sheath may, in fact, be considered to be in electrical contact with the earth along its entire length. From the point of view of corrosion however, either electrolytic or chemical, the metal sheath itself will not be in direct contact with the ground, since the conduction current in such a partially conducting material is electronic in character and is not due to the material becoming charged with moisture. The invention, while particularly applicable both to aluminium or copper-sheathed cables, can also be used on lead-covered cables which have to be laid in highly corrosive areas. Typical compositions which can be used for the covering are given in the specification.—*November* 28, 1956.

## HYDRAULIC MACHINERY

**763,557.** November 16, 1954.—HYDRAULIC SHOCK ABSORBERS, Newton and Bennett, Ltd., Valetta Road, Acton, London, W.3. (*Inventor: Noel Banner Newton.*)

One object of this invention is to provide a hydraulic stop without stressing the piston or its attachment and another to provide an improved construction of hydraulic stop for a piston type hydraulic shock absorber. As shown in the drawing, the hydraulic shock absorber is represented by the cylinder *A*, piston-rod *B* and piston *C*, the details of the usual piston-rod gland and hydraulic control passages and valves being



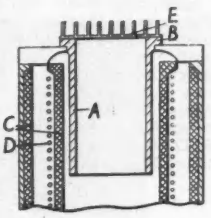

No. 763,557

omitted. Within the cylinder near one end is a disc *D* supported resiliently by a spring *E* so as to be held away from the end of the cylinder. On the piston-rod and secured by a spring ring *F* is a disc *G* carrying on its periphery a packing ring *H* and being formed with holes *J*. These holes are so positioned that they are covered by the disc *D* when the two parts are brought together, but are relatively large so that the disc *G*, though resembling a piston, provides little effective resistance to movement. In use, should the return or rebound movement of the shock absorber bring together the discs *D* and *G*, the passages *J* become closed to resist hydraulic flow from right to left and thus provide a hydraulic stop effectively resisting further relative movement of the piston towards that end of the cylinder. Relative movement of the piston in the other direction separates the discs which collectively had formed an effective auxiliary piston, whereupon hydraulic fluid can again flow relatively freely through the passage *J* and the disc *D* can be returned by its spring *E* to its normal position should it have become displaced to the right. The disc *G* need not necessarily carry a packing ring, as shock absorber action could be provided by permitting restricted hydraulic flow past the periphery of the disc. Again, shock-absorbing restricted flow passages can be provided in either of the discs *D* or *G* or between them so positioned that they are not closed when the discs are brought together.—*December* 12, 1956.

## INTERNAL COMBUSTION ENGINES

**763,492.** March 29, 1954.—CYLINDER LINERS, Wellworthy, Ltd., Radial Works, Stanford Road, Lymington. (*Inventor: John William Howlett.*)

According to the invention, a cylinder liner is hardened and tempered selectively so that, whilst the body of the liner has the required martensitic structure, the flange is left either in the "as-cast" condition or in such other condition as improves, or at least does not substantially reduce, its "as-cast" strength when tested by the Izod machine. Referring to the drawing, the liner *A* to be treated is of grey cast iron, having a pearlitic microstructure as cast, and is cast with an integral flange *B* at one end. The liner is placed in a furnace comprising refractory linings *C* and a heating element *D* with its flange *B* left protruding. The furnace may run at a temperature of between 885 deg. and 890 deg. Cent, so that whilst the greater part of the liner will be heated to this temperature the flange will not become heated above the change point. In order additionally to control the temperature of the flange it may be placed in contact with a member which dissipates the heat; for example, a ribbed cap *E* of good heat-conducting material, such as copper. If necessary, a current of air may be directed on to the ribbed cap in order to dissipate heat from the flange sufficiently to keep its temperature below the change point, which is approximately 760 deg. Cent. Thus when the liner is quenched in oil and tempered to a temperature between 370 deg. and 375 deg. Cent., it will be differentially hardened, the main part of the liner having a martensitic structure whilst the flange retains its "as-cast" or possesses an improved pearlitic structure. Modifications in liner treatment and the results obtained are also described in the specification.—*December* 12, 1956.

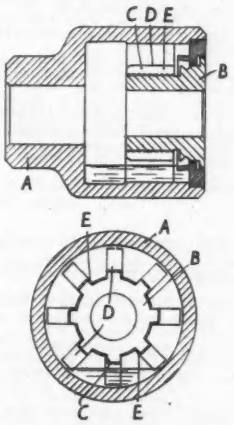



No. 763,492

## POWER TRANSMISSION

**763,157.** December 10, 1954.—GEAR COUPLINGS, Huttenwerke Ilsede-Peine Aktiengesellschaft, Peine, Hannover, Germany.

According to this invention, a relatively very thin elastic intermediate layer between the inter-engaging




No. 763,157

surfaces of the halves of a gear coupling suffices to deal with the requirements arising in practice. As the elastic material, a mixture of polyesters with di-isocyanates can be used, such as sold under the name "Vulkollan," in a thin layer, only about 1mm thick. As shown in the drawing, *A* is the outer coupling, half of which is shrunk on to the driven side of the shaft. *B* is the other half of the coupling. Only the operating surfaces *C* of the teeth *D* of the coupling part *B* carry on one side a thin, for example, 1mm thick, elastic layer *E*, for example, of poly-condensate. This material is sprayed on to and united with the metallic surfaces without using any binding means. In this way the diameter, the weight and hence the moment of inertia of the coupling are appreciably reduced as compared with known constructions. The new construction is simpler and cheaper to manufacture and the possibility and risk of destroying its elastic layer are very small, yet this layer is always able to take up any stresses occurring and so ensure a substantially smooth transmission of power. Other designs are also shown in the specification.—*December* 12, 1956.

## Launches and Trial Trips

COMMANDANT KERHNEL, cargo ship; built by the Chantiers Réunis Loire-Normandie for Marcesche and Co.; length overall 236ft 1in, length between perpendiculars 219ft 10in, breadth moulded 34ft 5½in, depth to upper deck 19ft 6in, draught loaded 14ft 3in, deadweight 1400 tons, service speed 11 knots; Sulzer 6.T.G. 36 single-acting, two-stroke diesel engine, built by the Chantiers de l'Atlantique, 900 h.p. at 260 r.p.m., reduction gear, 130 propeller r.p.m. Trial, November.

ENEE, cargo ship; built by the Anciens Chantiers Dubigeon for the Societe Navale Caennaise; length overall 288ft 7in, length between perpendiculars 265ft 5in, breadth moulded 40ft, depth to shelter deck 22ft 5in, draught 15ft 3in, deadweight 1470 tons; trial speed 15 knots; three holds, three bipod masts, six 10-ton derricks, hold capacity 98,500 cubic feet; one Sulzer single-acting, two-stroke, 6.SD. 60 diesel engine, built by Chantiers de l'Atlantique, 2400 service h.p. Trial, November.

## Forthcoming Engagements

*Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the* TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

### ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

*To-day, Jan.* 11.—STOKE AND CREWE BRANCH: Grand Hotel, Hanley, Stoke, "Electronics in Industry," E. Heys, 7.30 p.m.
*Mon., Jan.* 14.—CENTRAL LONDON BRANCH: White Hall Hotel, Bloomsbury Square, London, W.C.1, "Electric Motor Repairs," E. W. Hymas, 7.30 p.m. N.W. LONDON BRANCH: Century Hotel, Forty Avenue, Wembley Park, "Ultrasonics in Industry," W. Owen-Roberts, 8.15 p.m.
*Tues., Jan.* 15.—BOURNEMOUTH BRANCH: Grand Hotel, Firvale Road, Bournemouth, "Cathodic Protection," W. F. Higgins, 8 p.m.——LONDON NATIONAL LECTURE: E.L.M.A. Lighting Service Bureau, Savoy Hill, London, W.C.2, "Protective Multiple Earthing and Earthed Concentric Systems," S. J. Emerson, 6.15 p.m.
*Thurs., Jan.* 17.—KENT BRANCH: Rose and Crown Hotel, Tonbridge, "Colour Directional Light as Applied to the Stage," L. G. Applebee, 8 p.m.——SOUTHAMPTON BRANCH: Polygon Hotel, Southampton, "Electrical Accidents and Factory Regulations," S. J. Emerson, 8 p.m.
*Sat., Jan.* 19.—LIVERPOOL BRANCH: Visit to Mersey Tunnel, Control and Ventilating Station, 2.45 p.m.——OXFORD, READING AND DISTRICTS BRANCH: Regents Park College, Pusey Street, Oxford, "Interference Suppression," A. P. Hale, 6.30 p.m.

### BRITISH INSTITUTION OF RADIO ENGINEERS

*To-day, Jan.* 11.—SCOTTISH SECTION: Department of Natural Philosophy, The University, Edinburgh, "Potted Components and Assemblies," H. G. Manfield, 7 p.m.
*Wed., Jan.* 16.—S. WALES SECTION: Glamorgan Technical College, Treforest, "Radio Techniques in Post Office Engineering," C. T. Lamping, 6.30 p.m.
*Thurs., Jan.* 17.—SCOTTISH SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Industrial Applications of High-Speed Pen Recorders," R. Kasler, 7 p.m.

### COMBUSTION ENGINEERING ASSOCIATION

*Wed., Jan.* 16.—Engineers' Club, Albert Square, Manchester, "The Application of Back Pressure and Passout Generation," J. R. Wilkins, 10.30 a.m.

### COVENTRY ENGINEERING SOCIETY

*Tues., Jan.* 15.—College Theatre, Coventry, Eighth Herbert Lecture, 7.30 p.m.

### DIESEL ENGINEERS AND USERS ASSOCIATION

*Thurs., Jan.* 17.—Caxton Hall, Westminster, London, S.W.1, "World Supplies of Oil," M. E. Hubbard, 2 p.m.

### ILLUMINATING ENGINEERING SOCIETY

*Tues., Jan.* 15.—GLOUCESTER AND CHELTENHAM CENTRE: Fleece Hotel, Westgate Street, Gloucester, "X-Rays in Industry," K. R. Alsop, 6.30 p.m.——LIVERPOOL CENTRE: Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, "A Review of Street Lighting in Great Britain," C. C. Smith, 6 p.m.
*Wed., Jan.* 16.—N. LANCASHIRE GROUP: N. W. Electricity Board, 19, Friargate, Preston, "The New I.E.S. Code," H. C. Weston, 7.15 p.m.——TEES-SIDE GROUP: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "The Lighting of Small Factories," J. S. McCulloch, 6.30 p.m.
*Thurs., Jan.* 17.—MANCHESTER CENTRE: N.W. Electricity Board, Town Hall, Manchester, "The Evolution of the I.E.S. Code," H. C. Weston, 7 p.m.

### INCORPORATED PLANT ENGINEERS

*Mon., Jan.* 14.—DUNDEE BRANCH: Mathers Hotel, Dundee, "Experience in Component Manufacture," J. Lomax, 7.30 p.m.
*Wed., Jan.* 16.—KENT BRANCH: King's Head Hotel, High Street, Rochester, "Steam Raising by Oil Fuel," H. W. Hastings, 7 p.m.
*Thurs., Jan.* 17.—BLACKBURN BRANCH: Golden Lion Hotel, Blackburn, "Modern Chainmaking Techniques," W. Gibson Biggart, 7.30 p.m.——MERSEYSIDE AND N. WALES BRANCH: Stafford Hotel, City Road, Chester, "Instrumentation and Automation," R. J. F. Howard, 7.15 p.m.
*Fri., Jan.* 18.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Arc Welding," lecture and film, F. A. Thomas, 7.30 p.m.

### INSTITUTE OF BRITISH FOUNDRYMEN

*To-day, Jan.* 11.—TEES-SIDE BRANCH: Teesdale Hall, Head Wrightson and Co., Ltd., Thornaby-on-Tees, "The Practical Aspects of the Uses of $CO_2$ in the Foundry," G. B. Taylor, 7.30 p.m.
*Sat., Jan.* 12.—NEWCASTLE BRANCH: Neville Hall, Westgate Road, Newcastle upon Tyne, Discussion on Foundry Problems, 6 p.m.——SCOTTISH BRANCH: Royal Technical College, George Street, Glasgow, "Improvised Methods of Shell Production," T. H. Weaver, 3 p.m.
*Tues., Jan.* 15.—E. ANGLIAN SECTION: Public Library, Ipswich, "Foundry Developments," D. Killingworth, 7.30 p.m.——SLOUGH SECTION: High Duty Alloys, Ltd., Slough, "Coreblowing," G. W. Fearfield, 7.30 p.m.
*Wed., Jan.* 16.—SOUTHAMPTON SECTION: Technical College, St. Mary's Street, Southampton, Films, "The Kitimat Story" and "Aluminium Casting," 7.30 p.m.

### INSTITUTE OF MARINE ENGINEERS

*Mon., Jan.* 14.—STUDENT LECTURE: 85, The Minories, London, E.C.3, "Radio Aids to Marine Navigation," R. G. Swallow, 6.30 p.m.
*Wed., Jan.* 16.—S. WALES SECTION: College of Technology and Commerce, Cardiff, "Some Experiences in Vessels Equipped with Two-Stroke Harland and Wolff Opposed Piston Diesel Engines Using Boiler Oil," A. G. Arnold, 7.15 p.m.——MERSEYSIDE AND N.W. SECTION: Technical College, Birkenhead, "The Steam Reciprocating Engine," G. Yellowley, 7.15 p.m.
*Thurs., Jan.* 17.—KINGSTON UPON HULL AND E. MIDLANDS SECTION: Royal Station Hotel, Kingston upon Hull, "Ocean Highways," A. R. Kenworthy, 7.30 p.m.

### INSTITUTE OF METALS

*Tues., Jan.* 15—S. WALES LOCAL SECTION: University College, Singleton Park, Swansea, "Fatigue," P. Litherland Teed, 6.45 p.m.
*Thurs., Jan.* 17—BIRMINGHAM LOCAL SECTION: Exchange and Engineering Centre, Stephenson Place, Birmingham, "Some Metallurgical Aspects of a Gas Turbine Engine," S. Heslop, 6.30 p.m.

### INSTITUTE OF NAVIGATION

*Fri., Jan.* 18.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "The All-weather Operation of Transport Helicopters," P. A. Hearne, 5.15 p.m.

### INSTITUTE OF PHYSICS

*Fri., Jan.* 18.—NON-DESTRUCTIVE TESTING GROUP: 47, Belgrave Square, London, S.W.1, "Radiological Protection—the Present View," E. E. Smith, 6.30 p.m.

### INSTITUTE OF ROAD TRANSPORT ENGINEERS

*Tues., Jan.* 15.—WESTERN CENTRE: Royal Hotel, Bristol, "Exhaust Brake Design and Operation," A. G. Slee and W. K. Cox, 6.30 p.m.
*Thurs., Jan.* 17.—LONDON CENTRE: Royal Society of Arts, John Adam Street, London, W.C.2, "The Selection and Use of Petroleum Products for Road Transport," C. G. Tresidder, 6.30 p.m.——YORKSHIRE CENTRE: Great Northern Hotel, Wellington Street, Leeds, 1, "Wear and Tear," J. Johnson, 7.30 p.m.

### INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

*Mon., Jan.* 14.—NORTHERN CENTRE: N.E. Electricity Board's Lecture Theatre, Carliol House, Newcastle, "Modern Crop Spraying Technique," F. W. Morris, 6.45 p.m.
*Tues., Jan.* 15.—SCOTTISH CENTRE: Station Hotel, Perth, Discussion on "Agricultural Machinery," between Engineers and Local Farmers, 7.30 p.m.

### INSTITUTION OF CHEMICAL ENGINEERS

*Tues., Jan.* 15.—N.W. BRANCH: Grosvenor Hotel, Chester, "Vacation Training for Chemical Engineers," A. J. Carter, 7 p.m.
*Wed., Jan.* 16.—N.W. BRANCH: The University, Leeds, "Equilibrium Flash Vaporisation of Coal-Tar and Coal-Tar Fractions," D. K. H. Briggs and P. Popper, 7 p.m.

### INSTITUTION OF CIVIL ENGINEERS

*Sat., Jan.* 12.—MIDLANDS ASSOCIATION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Prestressed Concrete as Applied to Building Frames," Francis Walley and H. C. Adams, 6 p.m.
*Tues., Jan.* 15.—ORDINARY MEETING: Great George Street, Westminster, London, S.W.1, "Daer Water Supply Scheme," Harold Kerr and E. B. Lockett, 5.30 p.m.

### INSTITUTION OF ELECTRICAL ENGINEERS

*Mon., Jan.* 14.—INFORMAL MEETING: Savoy Place, London, W.C.2, Discussion on "The Influence of Maintenance Requirements on the Design of Industrial Electrical Equipment," opened by H. C. Fox and J. H. Harris, 5.30 p.m.
*Tues., Jan.* 15.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "Distribution of Power Supplies in Electrical Laboratories," opened by H. E. Dance and P. F. Soper, 6 p.m.——LONDON GRADUATE AND STUDENT SECTION: Public Library, Chelmsford, "Auto-following Radar Systems," J. A. Barber, 7 p.m.——S.E. SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, "A Transatlantic Telephone Cable," Mervin J. Kelly, Sir Gordon Radley, G. W. Gilman and R. J. Halsey, 7 p.m.
*Thurs., Jan.* 17.—UTILIZATION SECTION: Savoy Place, London, W.C.2, "Electricity in Modern Commercial Horticulture," C. A. Cameron Brown and A. W. Gray, 5.30 p.m.——N. MIDLAND CENTRE: Yorkshire Electricity Board, Ferensway, Hull, Chairman's Inaugural Address, W. F. Fleming, 7.15 p.m.
*Fri., Jan.* 18.—S. MIDLAND CENTRE: Town Hall, Birmingham, Faraday Lecture, "Nuclear Energy," T. E. Allibone, 7 p.m.

### INSTITUTION OF ENGINEERING DESIGNERS

*Mon., Jan.* 14.—N.E. BRANCH: Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, "Instrument Transformer Design," A. Wearmouth, 7.15 p.m.

### INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

*Tues., Jan.* 15.—39, Elmbank Crescent, Glasgow, "Experimental Techniques for Hydraulic Machinery Research," S. P. Hutton, 6.30 p.m.

### INSTITUTION OF MECHANICAL ENGINEERS

*To-day, Jan.* 11.—GENERAL MEETING IN CONJUNCTION WITH THE INTERNAL COMBUSTION ENGINE GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "An Analogue for High-Intensity Steady-Flow Combustion Phenomena," D. B. Spalding, 6 p.m.
*Mon., Jan.* 14.—EASTERN BRANCH AND LUTON A.D. CENTRE: Town Hall, Luton, Annual General Meeting, "Mechanical Breathing Machines," G. T. Smith-Clarke, 7.30 p.m.
*Tues., Jan.* 15.—INTERNAL COMBUSTION ENGINE GROUP: DISCUSSION: 1, Birdcage Walk, Westminster, London, S.W.1, "Is There a Future for the Diesel Engine in Combination with the Gas Turbine?" 6.45 p.m.——N.W. GRADUATES' SECTION: Engineers' Club, Albert Square, Manchester, "The Lubrication of Large Steam Turbines," J. A. McCurdy, 6.45 p.m.
*Wed., Jan.* 16.—YORKSHIRE BRANCH: The University, St. Georges Square, Sheffield, Annual General Meeting, 6.30 p.m. N.E., A.D. CENTRE: Chemistry Lecture Theatre, The University, Leeds, "Experiences During Forty Years of Automobile Design," A. G. Booth, 7.30 p.m.——LONDON GRADUATES' SECTION: 1, Birdcage Walk, Westminster, London, S.W.1, "Industrial Cooling Water Equipment," B. Colledge, 6.30 p.m.——WESTERN GRADUATES' SECTION: Grand Hotel, Bristol, "The Use of Brittle Lacquer in Experimental Stress Analysis," E. W. Parr, 7 p.m.
*Thurs., Jan.* 17.—CORPORATE MEMBERS ONLY: 1, Birdcage Walk, Westminster, London, S.W.1. Special Meeting to Consider Draft New By-laws and Regulations, 6 p.m.——N.W. BRANCH: Engineers' Club, Albert Square, Manchester, Annual General Meeting, "Power Station Auxiliary Plant," Geoffrey F. Kennedy and F. J. Hutchinson, 6.45 p.m.——E. MIDLANDS GRADUATES' SECTION: Room C4, The University, Nottingham, Film Show, 7.15 p.m.——YORKSHIRE GRADUATES' SECTION: Chemistry Lecture Theatre, The University, Leeds, "The Engineering Value of Motor Racing," Ian Appleyard, 6.30 p.m.
*Fri., Jan.* 18.—GENERAL MEETING: 1, Birdcage Walk, Westminster, London, S.W.1, Thomas Lowe Gray Lecture, "The Salvaging of Ships with Particular Reference to the 'Empress of Canada,'" W. R. Colbeck, 6 p.m.

### INSTITUTION OF MINING AND METALLURGY

*Thurs., Jan.* 17.—Geological Society, Burlington House, Piccadilly, London, W.1, "The Development of the Bancroft Mine," K. E. Mackay and J. D. Johnson; "Notes on Muscovite Mining in Southern Rhodesia," A. M. Bensusan, 5 p.m.

### INSTITUTION OF PRODUCTION ENGINEERS

*To-day, Jan.* 11.—DERBY SECTION: College of Art, Green Lane, Derby, "Time and Motion Study in the Automobile Industry," A. J. Hornsby, 7 p.m.
*Mon., Jan.* 14.—SHEFFIELD SECTION: Grand Hotel, Sheffield, "Material Handling," D. H. Outwin, 6.30 p.m.——YORKSHIRE SECTION: Hotel Metropole, Leeds, "Physical Testing Machines," W. R. Talbot, 7 p.m.
*Tues., Jan.* 15.—PETERBOROUGH SECTION: White Lion Hotel, Church Street, Peterborough, "The High Cost of Low Overheads," C. H. Starr, 7.30 p.m.——MANCHESTER GRADUATE SECTION: College of Technology, Sackville Street, Manchester, "Inspection as a Management Function," J. W. Wright, 7.15 p.m.——DERBY SECTION: Danum Hotel, Doncaster, "Materials Handling—A Challenge to British Industry," A. G. Hayek, 7 p.m.
*Wed., Jan.* 16.—EDINBURGH SECTION: North British Hotel, Edinburgh, "Computer Controlled Machine Tools," G. S. Kermack, 7.30 p.m.——W. GRADUATE SECTION: Grand Hotel, Broad Street, Bristol, "Consistency in Glass Fibre Reinforced Moulding," J. Rees, 7.30 p.m.——BIRMINGHAM SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Modern Techniques in Presswork," J. A. Grainger, 7 p.m.——WOLVERHAMPTON GRADUATE SECTION: Technical College, Wolverhampton, "The Production and Inspection of Screw Threads," C. H. Layne, 7.30 p.m.
*Thurs., Jan.* 17.—GLASGOW SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Profiling—Production Methods on Lathes," J. T. Lang, 7.30 p.m.——SOUTHERN SECTION: Polygon Hotel, Southampton, "Electrical Accidents and Factory Regulations," Col. Emmerson, 7.15 p.m.——LONDON SECTION: Royal Empire Society, Northumberland Avenue, London, W.C.2, "A Modern Inspection and Standards Room Practice," G. S. Sharp, 7 p.m.
*Fri., Jan.* 18.—GLOUCESTER SECTION: Wheatstone Hall, Gloucester, "The Ings of Industry," W. H. Telling, 7.30 p.m.

### INSTITUTION OF PUBLIC HEALTH ENGINEERS

*Tues., Jan.* 15.—Caxton Hall, Westminster, London, S.W.1, "Some of the Problems of Pumping Liquids," A. J. Clements, 6 p.m.

### INSTITUTION OF THE RUBBER INDUSTRY

*Fri., Jan.* 18.—LEICESTER SECTION: Bell Hotel, Leicester, "Modern Developments in the Use of Nylon in the Rubber Industry," J. M. Page, 7.30 p.m.

### INSTITUTION OF STRUCTURAL ENGINEERS

*Wed., Jan.* 16.—WALES AND MONMOUTHSHIRE BRANCH: Mackworth Hotel, Swansea, "The Design of Aircraft Hangars," J. M. Burke, 6.30 p.m.

### INSTITUTION OF WATER ENGINEERS

*To-day, Jan.* 11.—S.E. SECTION: Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, "The Water Supply of Singapore," W. S. Stredwick, 2.30 p.m.

### JUNIOR INSTITUTION OF ENGINEERS

*To-day, Jan.* 11.—ORDINARY MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Metal Bending," R. A. Johnson, 7 p.m.
*Mon., Jan.* 14.—SHEFFIELD AND DISTRICT SECTION: Livesey Clegg House, Sheffield, "Some Interesting Safety Devices," J. L. Faris, 7.30 p.m.——N.W. SECTION: Engineers' Club, Albert Square, Manchester, Chairman's Address, H. Smetburst, 7.30 p.m.
*Fri., Jan.* 18.—INFORMAL MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "The History of Diving," C. E. T. Warren, 7 p.m.

### MANCHESTER ASSOCIATION OF ENGINEERS

*To-day, Jan.* 11.—Engineers' Club, Albert Square, Manchester, "Arbitration and Awards," G. D. Walford, 6.45 p.m.

### NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

*To-day, Jan.* 11.—Mining Institute, Newcastle upon Tyne, "Comprehensive Trials of Complete Marine Propulsion Turbine Installations," H. E. C. Hims, 6.15 p.m.

### OLD CENTRALIANS

*Mon., Jan.* 14.—The Constitutional Club, Northumberland Avenue, London, W.C.2, "Handling of Radioactive Materials," J. R. V. Dolphin, 12.45 p.m.

### REINFORCED CONCRETE ASSOCIATION

*Wed., Jan.* 16.—11, Upper Belgrave Street, London, S.W.1, "Reinforced Concrete in Architecture," Edward D. Mills, 6 p.m.

### ROYAL AERONAUTICAL SOCIETY

*Thurs., Jan.* 17.—SECTION LECTURE: 4, Hamilton Place, London, W.1, "Electronic Control Techniques in Aircraft Manufacture," G. S. Kermack and H. Ogden, 7 p.m.

### SOCIETY OF CHEMICAL INDUSTRY

*Tues., Jan.* 15.—CHEMICAL ENGINEERING GROUP: 14, Belgrave Square, London, S.W.1, "The Use of Multi-Wall Paper Bags in the Chemical Industry," A. R. Hutchinson, 5.30 p.m.
*Thurs., Jan.* 17.—ROAD AND BUILDING MATERIALS GROUP: 14, Belgrave Square, London, S.W.1, "Refractory Concrete," T. D. Robson, 6 p.m.

## Advanced Engineering Courses

**Linear Programming Theory and Practice.** The University of Birmingham, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. One week course, January 28 to February 1. Fee £30 (covers full residence).

**Concrete Mix Design and Quality Control.** The Building Centre, Store Street, London, W.C.1. Course of eleven lectures commencing January 9. Wednesdays at 3.30 p.m. Fee £5 5s.